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"Blow Molding — Progress Report"

November 7, 1963

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"BLOW MOLDING - PROGRESS REPORT"

Regional Technical Conference

Sponsored by

Western New England Section

Society of Plastics Engineers, Inc.

November 7, 1963

"BLOW MOLDING - PROGRESS REPORT"

Regional Technical Conference of the Society of Plastics Engineers, Inc.

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Papers edited for publication by Armand G. Winfield and Robert D. Forger

- Papers are presented in program sequence -

PROGRAM

7:30 A.M.	Speakers' Breakfast	
8:00-9:00 A.M.	Registration	
9:00 A.M.	General Introduction	Merlin L. Evans (Plax Co.), Chairman, Western New England RETEC
Morning Session Moderator:	John M. DeBell, Chairman of the Board, DeBell & Richardson, Inc.	
9:15-10:00 A.M.	Keynote Address:	
	"Blow Molding - History, Growth Progress and Predictions"	C. Paul Fortner, Vice-President in Charge of Research, Development and Engineering, Plax Company
10:00-10:30 A.M.	"Large Blown Ware"	William A. Getz, President, Williams-White & Company
10:30-11:15 A.M.	New Materials Panel:	
	"Blow Molding of Teflon FEP" 5461-1	Dr. Donald I. McCane, Technical Representative, Technical Services Laboratory, E.I. duPont de Nemours & Co.
	"Blow Molding High Molecular Weight Polyethylene"	Norman M Burns, Engineer, Applications Research and Development Lab., Plastics Div., Union Carbide Corp.
11:15-11:45 A.M.	"New Trends in Blow Molding"	Melvyn A. Kohudic, Editor, SPE Journal
12:00-2:00 P.M.	Luncheon Program	
	Greetings and Introductions	Armand G. Winfield (Crystopal, Ltd.), President, Western New England Section
Luncheon Program Moderator:	William O. Bracken, Manager Packaging Development, Hercules Powder Company	
	"PAG's - The Technical Arm of SPE"	Guy A. Martinelli (Dimensional Pigments, Inc.), Vice-President, Engineering, Society of Plastics Engineers

PROGRAM (Cont'd.)

	"Soviet Impressions of American Science"	Dr. Paul R. Conroy, Chief, Professional Training, United States Information Agency
Afternoon Session Moderator:	Robert E. Dunham (Owens-Illinois), Past Chairman, Blow Molding PAG	
2:15-3:15 P.M.	Blow Molding Innovations Panel:	
	"In Plant Production of Plastics Containers"	Joseph Y. Resnick, President and William Jacobs, Technical Director, Questron America, Inc.
	"Parison Programming for Blow Molding"	Lloyd Kovacs, Development Engineer, Waldron-Hartig Division Midland-Ross Corporation
3:15-4:15 P.M.	Blow Molding Decorating and Finishing Panel:	
	"Spray Decorating Blow Molded Bottles"	Elmer Faber, President, Deco Tools, Inc.
	"Decoration of Polyethylene Blown Ware"	Gene Krupinski, Sales Manager, Silk Screen Division, Sinclair & Valentine Company
	"Decorating the Plastics Bottle"	L. E. Ritter, Field Service Engineer, Bee Chemical Company
4:15-4:45 P.M.	"The Reciprocating Screw Blow Molder	Herman R. Hutchinson, Product Specialist, Blow Molding Equipment, F. J. Stokes Corporation
4:45-5:15 P.M.	"European Blow Molding Technology as Emphasized at the Dusseldorf Kunststoffe, October, 1963"	Allan L. Griff, Plastics Consultant, Edison Technical Services, Inc.

Introducing RETEC Speakers . . . .

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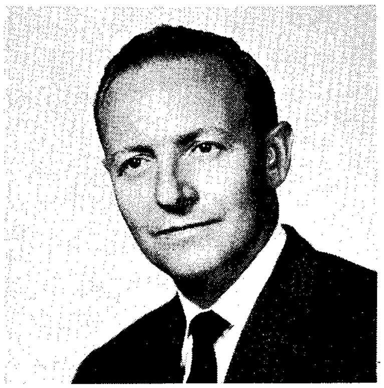

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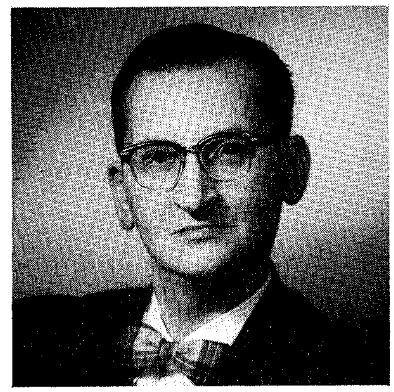

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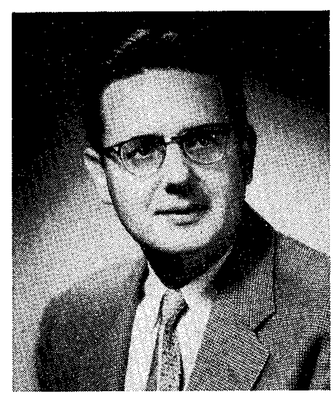
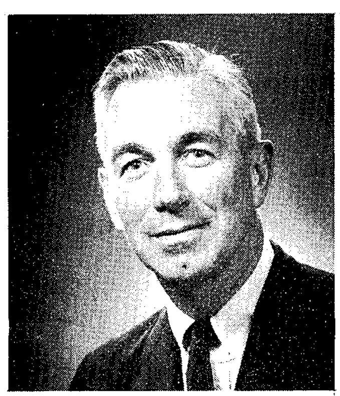


Robert E. Dunham
Afternoon Session

SPEAKERS

C. Paul Fortner



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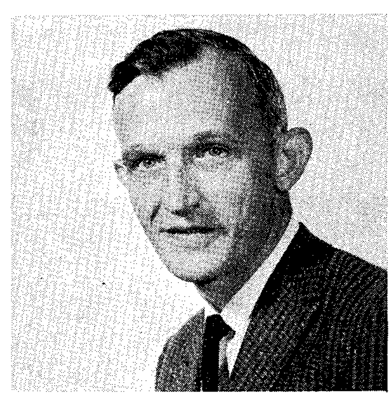
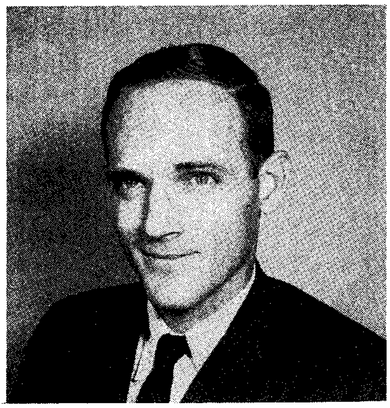


Donald I. McCane

SPEAKERS



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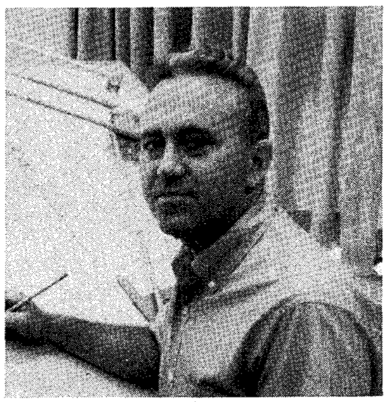

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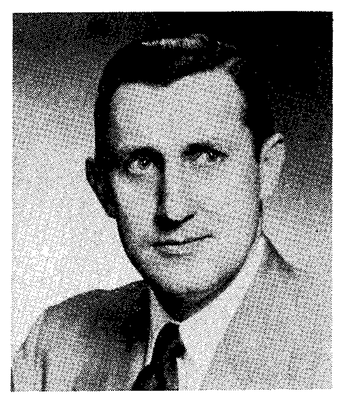

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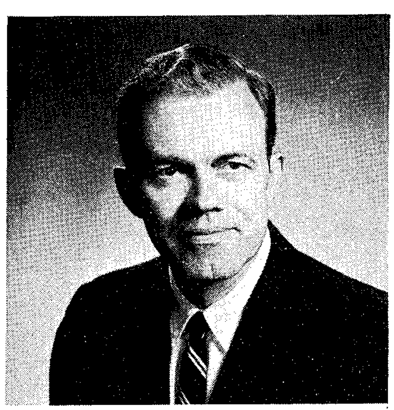
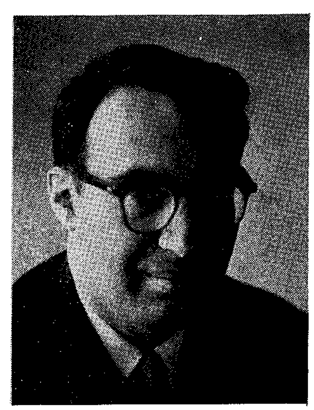


Herman R. Hutchinson



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"Introduction to Blow Molding - Progress Report"

Merlin L. Evans, RETEC Chairman

Monsanto Chemical Company
Plax Company Department
Bloomfield, Connecticut

This is the third Regional Technical Conference (RETEC) the Western New England has sponsored in recent years. "Plastics in Packaging" presented in 1958 and "Plastics - A New Dimension in Buildings" presented in 1961 were so well received that our Section now plans to sponsor RETECs as a regular part of its activities. We anticipate that every two or three years a progress report on technical developments in some phase of the plastics industry will be needed.

The rapid growth of blow molding has spurred the bottle packaging field to new standards and has opened new fabrication techniques for industrial applications. The resin sales have flourished, the equipment manufacturer has been challenged, the designer's scope has been broadened and the fabricator has been pushed to his maximum capability. The end result can be seen in every department store in the United States.

As a plastics engineer you are interested in efficiency techniques and expansion possibilities; as a supplier of more conventional packaging materials you want to know about your competition; as a large consumer of containers you want to investigate the possibility of in-plant production; and as a consumer you want to know what more can be expected from the blow molding industry.

This conference, "Blow Molding - Progress Report" presents a program designed to answer as many of these questions as possible and to predict and report the most recent technical progress in both resins and equipment.

About the Author........

Merlin L. Evans graduated from the University of Iowa in 1957 with a B.S. in Mechanical Engineering. In 1960 he received his M.S. in Management Engineering from Rensselaer Polytechnic Institute.

Mr. Evans joined the Plax Company in 1957 as a Development Engineer in blownware, sheet and film and two years later was elevated to Section Supervisor of Sheet and Film, the position he now holds.

Mr. Evans has published on thermoforming (Package Engineering, 1960) and is active in civic and professional activities.

Mr. Evans is Vice President of the Western New England Section of SPE, General Chairman of this RETEC, "Blow Molding - Progress Report" and a member of SPI and AMA.

Morning Session Moderator -

John M. DeBell, Chairman of the Board,
DeBell & Richardson, Inc.
Hazardville, Connecticut

John M. DeBell was graduated from Massachusetts Institute of Technology in 1917, in Chemical Engineering. He was in charge of the resin and plastics development activities of General Electric Company from 1922 to 1932, during which time he established General Electric as the third largest manufacturer of phenolic resins and varnishes in the country. At Hercules Powder Company from 1932 to 1936, he introduced ethyl cellulose into commercial production in the United States. At Fiberloid Corporation, 1936 to 1938, as director of research and development, he directed the development of polyvinyl butyral safety glass interlayer and the continuous production of cellulose acetate clear heavy film, and put these into manufacture, opening the way to the merger with Monsanto Chemical Company.

He has been consulting engineer to the plastics industry since 1939. With Henry M. Richardson, he set up the consulting and development firm of DeBell & Richardson where he was president through 1961 and chairman of the board thereafter. He is treasurer of D & R Pilot Plants and D & R Plastics Welders, two other organizations set up by Mr. Richardson and him.

During World War II, he was consultant to War Production Board and the Office of the Rubber Director. He was Advisor to the Office of the Quartermaster General and, with W. C. Goggin and W. E. Gloor, thoroughly investigated the German plastics industry for the Army, reporting the results in the volume, "German Plastics Practice". This was published by DeBell & Richardson, Inc., in the interest of American chemical firms.

BLOW MOLDING - HISTORY, GROWTH, PROGRESS AND PREDICTIONS

C. Paul Fortner

Vice President in Charge of
Research, Development and Engineering

Monsanto Chemical Company

Plax Company Department

Bloomfield, Connecticut

BLOW MOLDING! The term can be a catchall term covering many facets of a complex science and art, or a somewhat specific term (at times an epithet) depending on the user, and with the individual varying with his mood of the moment. Certainly, at the Plax Company, we use it in a variety of ways. In the most common and broadest sense we think of it as a process for forming hollow plastics items by shaping them while in a formable state by means of internal fluid pressure.

Whether the first shape is attained by extrusion of a tube, injection molding, forming from reheated plastics sheet or even from solvent softened material, it is still eventually "blown up", hence blow molded. I do know that many who work from hot extruded tubes are inclined to feel that they are the "true blow molders"; while those using reheated sheets are more truly employing a variant of "pressure forming". After all, however, what is "pressure forming" except different words meaning about the same thing?

When we study the history of man, we find that he has always been concerned with getting or making hollow things: to hold or store his possessions - water or grain; to keep the elements or animals out of his cave or hut; or to provide sufficient buoyancy to make things float - fishing floats or boats. The first hollowed fabrications were to remove something from the earth to make caves or from gourds to make scoops. The progression eventually evolved to shaping and putting together wood, hides or metal to obtain hollow "things". Mud and clay provided the first step to seamless fabricated articles and later ceramics and glass provided more sophisticated vessels.

Because of this early art developed over many centures, it is often said that we in blow molding do nothing NEW. But I will argue that we are doing something new every day. It is often easier for me to illustrate with an example. Several years ago, Plax was first to offer, we think, an opaque polyethylene bottle with a window in it so the liquid level could be observed. It appeared to several of us that since no such bottles were available and we had seen none, that this was new and novel. However, a search of the patent files disclosed Patent #1,203,448 to A. A. Ainsworth on October 31, 1916, filed December 23, 1913, which claimed "A container comprising opaque or translucent and transparent coherent parts of the same material, the opaque or translucent part protecting the contents of the container from the deleterious action of light rays, and the transparent part providing a sight panel to permit the contents to be examined".

Obviously we were not first, though maybe the first with polyethylene. Further investigation revealed a patent in the late 1800's with a simpler and broader claim, so even Ainsworth was not first with the basic idea. It is probable that some early man put thin membranes in the side of his hut to see out, or in his mud vat to see liquid level. But we were still first with a flexible or impact resistant container and the manufacturing techniques were NEW. (I think).

I am sure that at this conference we will hear some good papers on how some effects are achieved. Certainly Ferngren, in his Patent #2,128,239, application February 25, 1933, did not tell us enough about how he achieved "the required thickness of plastics material deposited along said wall being readily predetermined by suitable variation in the rate of elevation of the tube and the quantity of material extruded from the passage". I anticipate that "programmed extrusion" and the various means of achieving it will provide this industry with many an interesting discussion, paper, and even argument. I expect this conference to have several.

This brings me to a knotty point, or impertinent question. How technically valid will these papers be, and how detailed? Along with the mechanical details and possible samples, will there be adequate data to relate the results to a variety of resins? Will there be enough data on the effects of temperature, pressure, additives or pigments? I sincerely hope so. However, I have found in a good many years of association with plastics, and especially "blow molding", that the things we prove "impossible" today become possible or even easy tomorrow, when something changes, such as the scope of the temperature viscosity curve or the shear rate at which melt fracture occurs. Sometimes we have not known why "it" works now and did not then. That, of course, is because we have been in the simultaneous developmental-engineering stage on the plastics themselves along with the machinery for them. We are still learning how to measure those things that affect our engineering-handling of them. The carefully proven limits of a process of yesterday, well documented with reams of test data, suddenly are no longer valid limits, and in some instances in my experience it has been hard to find out "why". It has seemed that none of the known resin parameters could be the answer. So we must still have a long way to go in learning how and what to measure to get the data I think we need as engineers. I admit, on the other hand, that the press of business for its first objective - to make a profit - sometimes seems to dictate short cuts or bobtailing data gathering and analysis, but this is not true to the extent that many engineers of my acquaintance delude themselves into thinking.

I have heard many discussions, participated in countless arguments, but still have nothing to really use as proof as to how much of the screw surface should be polished and how much etched, and how coarse the etching should be, or the importance of the surface transition. Or does it really matter in the operation of the extruder, and is surface only important when it comes to cleaning the screw? I am interested in this problem, but I will admit I have not been enough so as to have much time spent on it in our laboratories. But, as I think sometimes of the reams of data we have accumulated on other problems with little apparent concrete conclusion, I am not too sure I have been right. It just might be important on some resins I did not have to run when I personally was running screw tests and developing ideas about what not to let other people do with extruders.

The other day, I was reviewing some of the pages and pages of data, charts and graphs we had compiled in a tests, trying to tie down the variables in the erratic behavior of a specific high density polyethylene with a specific antistatic additive. Seventy-eight runs had been made to "tie down the variables" and I will have to admit that most of the variables assumed that the L/D ratio and screw finish had nothing to do with the problem. At least they were constant in this

series of tests. We did, though, check the effect of metallurgy of our extruders in the barrels, barrel liners, heads, screws and screw lands which we have bought over a series of years. This because of apparently opposite results from supposedly identical machines (in different factories but run by the same engineer). It would have helped in this test series, too, if we, or maybe I should say I, had really had faith in the test methods for measuring the degree of antistatic effectiveness. Sometimes things work in such a way with plastics that the method and manner of measuring is developed concurrently with the means of control. I believe the early development of the melt indexer was in that category, too.

Do we then know enough about "programmed extrusion" to predict with any degree of certainty what changes in our setup must be made when we change to a resin with an antistatic additive (which, in turn, probably necessitated a change in antioxidant or antioxidant level) which may in turn change the shear and the puff-up rates? If we do, we are working in a science, but I suspect it will be art that gets the blownware out of the machine.

Have some of the "new" things like programmed extrusion become popular because of improved extruder technology - break through in die design, or because of improved resin or smarter engineers? I, for one, think it was both resin and machine technology. As more uniform resin became more uniformly processable, it became possible to develop (on purpose) controlled surging or controlled variations of the kind we had been trying to get out of the machines for many years. So, of course, the means of developing these controlled variations are as diverse as the original means to control them. Even Plax's own "Color Tex"* color effect depends on complete, uniform, dependable color mixing and uniform flow properties of resins to make the effect reproducible. Without both we could not do it on a production basis. This is a good place for the old reliable quote "About the easiest thing in plastics fabrication is to blow a bottle, but the hardest is to blow a million identical ones".

I want to go back to an earlier theme. What you prove today is not necessarily so tomorrow, unless you really investigated all parameters - and even then, maybe.

We in Plax approached high-density polyethylene as a new and different resin from low density. At least we told each other we were trying to do just this. But right now, after many millions of pounds of high-density use, we are still finding that things we tried with low-density in 1948-1954 and abandoned as mechanically not usable with polyethylene, do work on high-density. Although we thought we approached it as a new material, the approach was a qualified one. Unfortunately, policy does not permit illustrating this point with a concrete example. We hope you did not think to try the old failures on the new resins, or if you did not have the old failures to try, that you did not think of it at all. Or may I should not admit we have had any old failures; at any rate I cannot illustrate the point, but it is true, nonetheless.

To me it is more frustrating to see someone else use a technique we "proved" impracticable or inoperative some years ago and have substantial success with it, than to see the success in something we did not try - at least that does not show us off to such bad advantage to ourselves - but I do not want to overplay the point. There is much new and completely original engineering being done in blow molding and much which will be done. With the reducing costs of resin and improving blow molding technology, the day of the single trip all plastics motor oil bottle, quart milk bottle, baby food jar or dog food container gets closer and closer with the changing improvements.

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*Monsanto Trade Mark

For a machine to produce 1,000 quart bottles per minute, what will be the optimum extruder (or multiple extruders) and how will this compare to the extruder or extruders necessary to produce fifty-gallon drums at a high speed; what will be the optimum number of orifices for extruded tubes (or will it be injection molded blanks) and at how many per machine? Will the resin changes make more possible and usable the "press and blow" technique with its apparent freedom from melt fracture and apparently simpler mechanisms for high speed operation, or will the twin flat sheet method become dominant by virtue of a good solution to the trimming problem? How much of the automobiles will be blow molded, and how about more of the furniture as a step beyond the blown toys? Blow molding can and will do all these things as we as engineers find out enough about the variables to design the machines of the future.

About the Author........

C. Paul Fortner was born in Sterling, Colorado in 1912 and received his B. S. in Mechanical Engineering in June 1935 from Colorado State University.

From 1935-1940 Mr. Fortner was in retail sales, commercial photographer and labratorian for the Great Western Sugar Company and later as Technical Service Engineer at the Gates Rubber Company.

From 1941-1952 he was with the E. I. duPont de Nemours & Co., Inc., working in various branches such as Remington Arms in Bridgeport, Connecticut and in Denver, Colorado, in the Atomic Energy (TNX) at Oak Ridge, Tennessee and in the Plastics Department in Arlington, New Jersey where he was in charge of the development of extrusion techniques at the Arlington Field Service Lab.

From 1952-1961 he has been with the Plax Corporation progressing from Assistant Director of Research to Director (1953) to Vice President in charge of Research (1954). In 1961, Mr. Fortner became President of Fernplas Corp., a wholly owned subsidiary of Plax.

On September 28, 1962, he became Vice President - Research, Development and Engineering for the Monsanto Chemical Company, Plax Company Department and the same year became a Director of Plax Canada and Sidaplax, Belgium.

Mr. Fortner belongs to many civic and professional organizations, including the Lions, Bloomfield Volunteer Fire Department, and the Colorado Society of Engineers, and SPE (Western New England Section). He is a licensed professional engineer in New Jersey and Connecticut.

He has written numerous articles on plastics and has been a speaker at the 1953 ANTEC. He is listed in American Men of Science, 9th Edition, and in Monthly Supplement (Marquis Company), April, 1955.

LARGE BLOWN WARE

William A. Getz

President

Williams-White & Co.

Rock Island, Ill.

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RETEC AS A SUPPLEMENT

About the Author........

William A. Getz was born in Holland, Michigan, in 1915. He attended Augustana College in Rock Island, Illinois.

Mr. Getz was with International Harvester Company from 1935 to 1938 as a tool room trainee and has been with the Williams-White Company since 1938. He began in Sales and Service. In 1941 Williams-White moved him to their allied plant, Moline Forge, Inc., to become Plant Superintendent and to supervise a shell forging program.

In 1955 Mr. Getz was made Vice President of Williams-White and became President in 1961. He is also President of Moline Forge, Inc.

In addition to plant activities he is active in his community as Director of Illinois Blue Cross Plan, Director of Associated Industries (Quad Cities), President of the Board of Moline Public Hospital and Republican Chairman of Rock Island County, Illinois.

BLOW MOLDING OF TEFLON® FEP

Donald I. McCane

Technical Services Laboratory

E. I. du Pont de Nemours & Co., Inc.

Wilmington, Delaware

INTRODUCTION

Teflon® FEP-fluorocarbon resin is a thermoplastic copolymer of tetrafluoroethylene and hexafluoropropylene. It has been processed by conventional techniques used for other thermoplastics such as melt extrusion, injection molding, compression molding and fluidized bed coating. Many secondary operations, including spin welding, vacuum forming and heat sealing, may also be performed with this material.

Because of the outstanding melt strength and excellent melt draw-down of "Teflon" FEP, this material is readily adaptable to various blow molding processes. The processing technique is particularly suitable in fabricating end-use articles with thin sections and large surface areas from highly viscous resins, such as "Teflon" FEP, where injection molding may be limited by conditions of unstable resin flow which lead to melt fracture and constitute a product quality problem.

PROPERTIES OF "TEFLON" FEP

There has, on occasion, been some confusion concerning the similarities and differences between "Teflon" TFE and "Teflon" FEP. As illustrated in Figure 1, "Teflon" TFE-fluorocarbon resin is a homopolymer of tetrafluoroethylene of extremely high molecular weight. "Teflon" FEP - (fluorinated ethylene propylene) fluorocarbon resin is a copolymer of tetrafluoroethylene and hexafluoropropylene. In view of the fact that both polymers contain only the elements of carbon and fluorine, the resins exhibit many similar properties such as continuous service at highly elevated temperatures in corrosive environments while maintaining excellent mechanical and electrical properties. The properties of antistick and low coefficient of friction, possessed by both resins, may also be associated with the elemental likeness of the polymers. As there are similarities in the properties of the resins, so are there significant differences. These differences, molecular in nature, arise from the facts that "Teflon" FEP is a copolymer and the melt viscosity of "Teflon" FEP is considerably lower than that of "Teflon" TFE. Some of the important differences in the properties of "Teflon" FEP and "Teflon" TFE are noted in Table I.

Fundamentally, the most significant difference between "Teflon" FEP and "Teflon" TFE is that "Teflon" FEP is a thermoplastic resin which can be melt processed in conventional plastics molding and extrusion equipment whereas "Teflon" TFE cannot.

Teflon® DuPont Registered Trademark

PROCESSING

"Teflon" FEP is readily extruded at reasonable rates in conventional melt extrusion equipment. Suggestions on extrusion equipment, processing techniques and handling procedures given below are common to thermoplastics in general, however, emphasis has been placed on those requirements and conditions particularly applicable to the extrusion and blow molding of "Teflon" FEP resin.

A. Extrusion Equipment

1. Extruder

Since extrusion rates for "Teflon" FEP are almost always limited by maximum resin flow through the die rather than by extruder plasticating capacity, relatively small extruders are adequate. A two-inch extruder provides the best versatility for making a wide variety of extruded products. Long barrel extruders are desirable because they provide greater heat transfer area and thereby facilitate uniform melting of the resin. Length to diameter (L/D) ratio of the barrel should be 20:1 or 21:1. Ratios as low as 15:1 have been used, however, at reduced extrusion rates.

Extruders used with "Teflon" FEP should be capable of reaching temperatures up to 800°F. Electrical heater bands rated at 25 to 35 watts/sq. in. are normally used. The barrel should preferably be divided into 3 or 4 independently controlled heating zones, each equipped with its own thermocouple and temperature indicating controller.

Many types of drive mechanisms are used with extruders processing "Teflon" FEP. Horsepower requirements are not appreciably greater than for other thermoplastics. Motors as small as 10 h.p. have been used for two-inch extruders. Speed of the screw will, of course, vary with the type of extrusion, however, for flexibility a range of 3 to 100 rpm is desirable.

2. Screw

A metering-type, rapid-compression, constant pitch screw, divided into three sections, is recommended for the extrusion of "Teflon" FEP. In general, the ratio of the channel depth in the feed section to that in the metering section should be approximately 3:1. Transition occurs abruptly over about one-half turn of the screw as an involute compression. The metering section should comprise about 25% of the total length of the screw. The depth of the channel is shallowest in this section. The screw is designed so that the metering section controls delivery and always runs full. The forward end of the screw should have a slightly conical or rounded nose to avoid areas of stagnant flow and possible decomposition of the resin.

3. Melt Thermocouple

Because of the importance of precise temperature control in extruding this resin, a thermocouple is used to measure the temperature of the melted resin. This "melt thermocouple" is located downstream from the breaker plate and should be totally enclosed

by and located at the tip of a 1/8-inch Hastelloy® C tube. In order to penetrate as near as possible to the center of the melt stream and to minimize the effect of any heat transfer from the barrel, the tip of the melt thermocouple should extend at least 1/2 to 1 inch from the wall.

4. Crosshead and Die

In designing a crosshead, extreme care should be taken to obtain good streamlined flow and to avoid any unnecessary hold-up spots. The design of streamline flow is particularly important in the throat section of the crosshead where the direction of flow is changed 90°. A "flow splitter" should be used on the downstream side of the throat to cause the flow to split into two equal streams 180° apart. Long land tubing-type dies are used to avoid surging and to permit high extrusion rates. The approach angle to the die is not critical but should not exceed an included angle to 60°.

The temperatures of the crosshead and any adapters should be maintained by independently controlled heater bands in conjunction with thermocouple and temperature indicating controllers.

5. Materials of Construction

Corrosion-resistant metals should be used for extrusion equipment processing "Teflon" FEP. The rate of corrosion encountered in an extruder is negligible in terms of dimensional changes; however, traces of corrosion products which build up on the surface of certain types of metals will break away from the metal surface and contaminate the finished product. Maximum protection against corrosion and product contamination can be obtained from "Hastelloy" C for screw, adapters, crosshead, dies and breaker plate and from Xaloy® 306 for barrel liners. Other high-nickel alloys such as Duranickel® may prove a suitable substitute for "Hastelloy" C. No stainless steels have been found satisfactory for long-term corrosion protection. For short experimental runs, chrome plating of 3 to 4 mils can be used satisfactorily.

The materials of construction for blow molds are numerous and the use of any one is a compromise of economics based on production rates limited to set-up time (thermal conductivity), replacement costs (wear resistance) and initial investment (mold cost). The relative performance in each of these areas of various materials of construction for blow molds is tabulated in Table II.

B. Processing Conditions

1. Extrusion

Because of the relatively high viscosity and melting point (approximately 545°F) of "Teflon" FEP, high extrusion temperatures

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Hastelloy® - Haynes-Stellite Registered Trademark
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Duranickel® - International Nickel Co. Registered Trademark

are required to process this material. The outstanding thermal stability of "Teflon" FEP permits a wide range of melt processing temperatures. The melt temperatures usually range from 600 to 720°F and are controlled principally by adjustments in the barrel temperatures. Above 720°F, degradation of the resin can occur. Degradation of the resin is readily apparent by discoloration and/or the formation of small bubbles in the extrudate. For most blow molding operations, melt temperatures in the range of 600 - 650°F are best. The heaters on crossheads, adapters, clamps, dies and manifolds are used only to prevent loss of heat from the resin and maintain isothermal conditions. Therefore, the temperature of these parts should be controlled close to the temperature of the melt.

A typical set of extrusion conditions for parison formation from a tubing die with an I.D. of 0.500" and a mandrel of 0.200" O.D. using a two-inch extruder with a L/D of 20:1 is shown in Table III. The temperatures recorded in the table are measured by thermocouples imbedded deeply into the wall of the cylinder and hence provide a closer indication of the actual resin temperature in the cylinder.

2. <u>Blow Molding</u>

"Teflon" FEP may be blow molded under a wide range of blow-pressures, mold temperatures and mold close times. Because of the excellent melt drawability of the resin, blow mold pressures as low as 12 psi have been used. Pressures as high as 60 psi have, in some instances, been employed; however, best results are generally obtained using a blowing pressure of approximately 30 psi. Air may be used as the blowing agent. Mold close time depends principally on the thickness of the part being molded, although, mold close times as low as 12 seconds are possible without distortion of the shape of the part or sticking in the mold. Mold temperatures in the range of 130 to 185°F have been used with good results, however, a mold temperature of 145°F appears optimum for most operations.

DISCUSSION

Blow molding is being recognized as an effective processing technique for converting thermoplastics into useful endproducts. However, the need for improved properties such as chemical and stress crack resistance is leading the industry toward the use of higher molecular weight, more viscous materials. This trend toward higher molecular weight materials to gain the desired property improvements is placing a greater strain on current processing techniques for converting thermoplastic resins at economical rates into consumer items.

With any thermoplastic, by any processing technique, the resin must be melted and eventually forced, under pressure, through some type of restricted orifice or aperture thus setting up shear stresses. All thermoplastics have a critical shear rate at which point a condition of unstable melt flow will occur when the material is processed at high rates through a restricted opening. This condition, called melt fracture, is actually a tearing of the resin caused by excessive shearing action within the restriction and leads to surface roughness in the extrudate. At onset, it appears as cloudiness in the melt. As it becomes more severe, a distinct scaly

appearance occurs on the surface of the stream of resin. While melt fracture can occur with any thermoplastic, it occurs more readily with the more viscous resins such as "Teflon" FEP. Figure 2 shows some rheological data for "Teflon" FEP at 735°F and compares them with Alathon® 10 (430°F) and Zytel® 101 (575°F).

One highly successful technique for fabricating "Teflon" FEP into complicated shapes is injection molding. However, due to the melt viscosity characteristics of "Teflon" FEP, limitations are placed on what actually can be done by injection molding. With most thermoplastics it is usually difficult to mold very thin sections, particularly if large surface areas are involved. In the case of "Teflon" FEP, a "thin" section may be considered to be anything below about 0.040". The problem, to obtain both a full shot and a smooth surface, is basically one of heat transfer. Below about 0.040 - 0.060" thickness, resin freezes before significant flow is obtained. Thus, a fast ram speed and hence a high shear rate must be used for molding thin sections since a full shot is of primary importance. A high shear rate leads to melt fracture which in turn affords parts of poor quality due to surface roughness and delamination. Blow molding of "Teflon" FEP, on the other hand, is not limited by surface area and thin section considerations and, therefore, offers a distinct advantage over injection molding in fabricating hollow articles of such configurations.

One technique for reducing the tendency for melt fracture to occur in injection molding is to increase the critical velocity or shear stress of the resin. This is achieved by using a high stock temperature since the critical velocity increases as the resin melt temperature increases. However, the possibility exists that too high a melt temperature may be used in an attempt to fill a thin section by injection molding and degradation of the resin will occur with attendant loss in physical properties resulting in poor quality. Figure 3 shows the change in viscosity with temperature for "Teflon" FEP.

Since melt temperatures in forming a parison of "Teflon" FEP for blow molding rarely exceed 650°F, problems of resin degradation are, for all practical purposes, nonexistent. With extrusion melt temperatures of 650°F or less, the resin may be reworked as many as six times without any measurable change in melt flow number. A word of caution on reworking material is perhaps appropriate at this time. The resin must be kept free of all contamination of carbonaceous material such as oil, grease or even atmospheric dust. At the high processing temperatures required to fabricate "Teflon" FEP, most other organic materials are thermally unstable and will decompose into carbon. It requires only a trace of carbon to give the resin an off-white, grayish or brown appearance which will detract from the final product quality. If rework resin develops a gray color, it may be whitened to some extent by heating in an air oven at temperatures up to about 500°F for 24 hours.

APPLICATIONS

In commercial applications, "Teflon" FEP has been blow molded into bottles as large as 32 ozs. and beakers up to a size of one liter. In these applications, advantage is taken of the resin's low permeability, excellent corrosion resistance to nearly all chemicals and outstanding physical properties at high and low temperatures. These shatter-proof bottles and beakers can be used for virtually all hazardous liquids at freezing and boiling temperatures. They provide excellent handling properties under the most demanding conditions and are designed and

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constructed to resist severe punishment over an unusually wide temperature range of -250°C to +200°C. These articles can be repeatedly sterilized by all processes without harm. The excellent anti-adhesion properties allow for thorough, easy cleaning. Considering the large surface areas and draws of these articles, it is problematical that they could be injection molded at wall thicknesses thin enough to make them economically attractive.

Another application in blow molded "Teflon" FEP is found in the fabrication of gaskets or seals of rather complex radii. Here a section of six or eight seals is blown and then sliced to close tolerances into individual gaskets. The gaskets are placed in a service requiring outstanding corrosion resistance.

The growth in applications of blow molded "Teflon" FEP should increase rapidly as the industry becomes more familiar with the resin's unique combination of properties and ease of processing.

About the Author........

Dr. Donald I. McCane is a member of the Du Pont Company, serving as a Technical Representative for the Plastics Department at the Technical Services Laboratory at Chestnut Run.

He received his undergraduate training at Yale University and, in 1953, was granted a PhD. in Organic Chemistry by the University of Michigan. His activities with Du Pont included fundamental research in fluorocarbon chemistry, process improvements in nylon intermediates and plant experience in the manufacture of Delrin and Teflon.

Dr. McCane is currently engaged in sales service work, responsible for processing technology of "Teflon" FEP.

TABLE I

DIFFERENCES IN THE PROPERTIES OF "TEFLON" FEP AND "TEFLON" TFE

Property	"Teflon" FEP	"Teflon" TFE
Melting point, °F	545 - 565	621
Continuous upper service temperature, °F	400	500
Flex life	Good	Excellent
Clarity	Transparent	Opaque
Melt processable	Yes	No

TABLE II

MATERIALS OF CONSTRUCTION FOR BLOW MOLDS

Material	Thermal Conductivity, BTU/sq. ft./°F/in.	Wear Resistance	Comparative Cost
Aluminum	1400 (Excellent)	Fair	Low
with steel inserts	-- (Good)	Good	Low
Beryllium copper	650 - 750 (Good)	Good	High
Tool steel (SAE 1020)	300 (Poor)	Excellent	Medium
Zinc alloy	780 (Good)	Fair	Low
Cast iron	380 (Poor)	Good	Medium

TABLE III

TYPICAL EXTRUSION CONDITIONS FOR "TEFLON" FEP

Barrel rear, °F	550
Barrel center, °F	620
Barrel front, °F	630
Crosshead, °F	610
Melt temperature, °F	620
Screw speed, rpm	30

MOLECULAR STRUCTURES OF TEFLON® TFE AND TEFLON® FEP

$$CF_2 = CF_2 \longrightarrow (-CF_2-CF_2-CF_2-CF_2-)_n$$

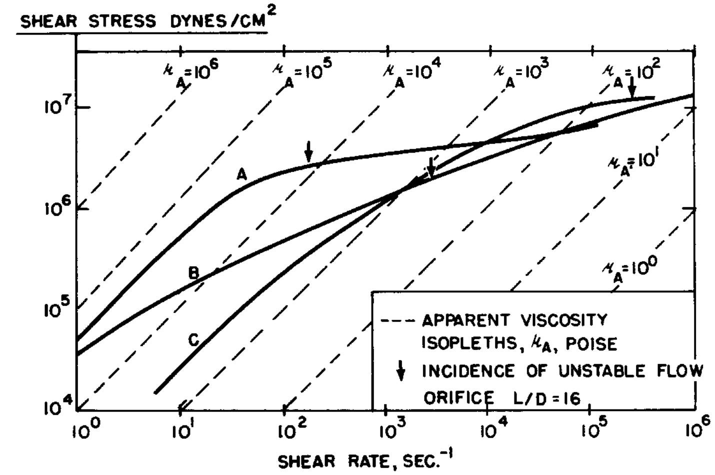
TETRAFLUOROETHYLENE "TEFLON" TFE

$$CF_2 = CF_2 + CF_2 = \underset{\displaystyle CF_3}{\underset{|}{CF}} \longrightarrow \left(-CF_2-CF_2-CF_2-\underset{\displaystyle CF_3}{\underset{|}{CF}}-\right)_n$$

TFE HEXAFLUOROPROPYLENE "TEFLON" FEP

FIGURE 1

FLOW CHARACTERISTICS OF TEFLON® FEP



CURVE A "TEFLON" FEP AT 735°F
CURVE B "ALATHON" 10 AT 430°F
CURVE C "ZYTEL" 101 AT 535°F

FIGURE 2

CHANGE IN VISCOSITY WITH TEMPERATURE TEFLON® FEP

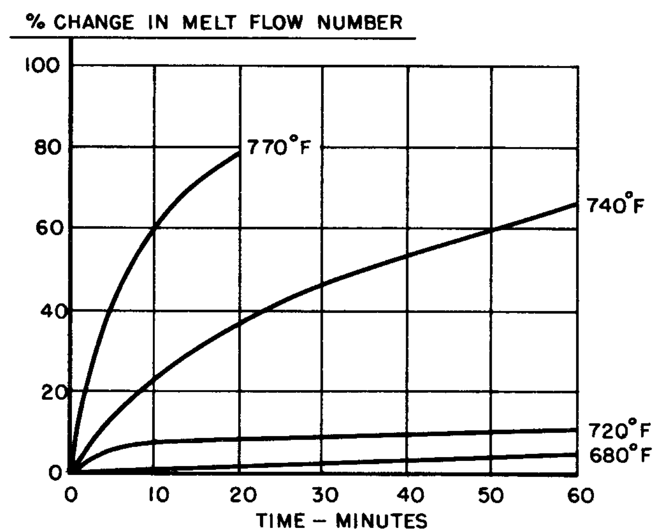


FIGURE 3

BLOW MOLDING HIGH MOLECULAR WEIGHT POLYETHYLENE

Norman W. Burns

Engineer

Applications Research and Development Laboratories

Plastics Div., Union Carbide Corporation

Bound Brook, New Jersey

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AS A SUPPLEMENT

About the Author........

Norman M. Burns graduated from the University of Delaware in 1956 with a B.S. in Chemical Engineering. He joined Union Carbide immediately upon graduation and has been with them ever since. His experience in the Applications Research and Development Department has included developing thermoplastic products for use in molding processes. The bulk of this experience, however, has been concerned with the blow molding of polyolefins.

NEW TRENDS IN BLOW MOLDING

Melvyn A. Kohudic

Editor, SPE Journal

Society of Plastics Engineers, Inc.

Stamford, Conn.

INTRODUCTION

There are enough of the elements of chance in today's blow molding industry to compare it to one big poker game. The stakes are certainly high enough. And there are enough new and proprietary developments in blow molding machinery, new resins, and changing pricing policies to give companies involved ample opportunity to bet the value of their hands in winning the blow molding business pool. It's an industry where, instead of one player studying the face of another for some expression that would give away his hand, companies read each other's advertisements and try to determine if a big account has been cracked by noting whether the advertising has "general" shapes or if they advertise an actual case history.

It is against this background that this paper will attempt to put into focus the various developments and trends which appear to be emerging from the industry. So that these developments can be viewed in proper perspective, it should be realized that the blow molding industry, as characterized today, is 60 to 70% concentrated in satisfying the demands of plastics bottle users. The balance of production goes into automotive uses, appliance and business equipment, and such industrial and miscellaneous items as housings for hair dryers, pipe fittings, lawnmower housings and lounge chairs.

TECHNICAL CHANGES IMMINENT

An area in which the most profound change will take place is rate of plastics bottle production. The industries who are buying our plastics bottles very seriously classify the bottle blowing business, as it exists today, a horse-and-buggy business. They're used to glass bottle production rates of over 100,000 per machine per day. The best we can give them in plastics bottles is 6000 - 10,000 per machine per day.

Production rates will go up as a result of both improvements in machinery and resins. In machinery, the development most likely to appear first will be machines which produce a finished bottle in the mold. In other words, reaming and deflashing will not be necessary. Cycle time will be further reduced by improvements in the processability of resins - faster curing resins.

Another area of considerable developmental activity is in methods for preshaping the parison. This is important because it allows the production of bottles having thinner wall sections. Presently several methods are used to vary the

shape of the parison, such as variable extrusion speed or, if an accumulator is used, by varying the pressure in the accumulator. The ultimate in pre-shaping the parison is to produce a parison having roughly the shape of the bottle to be blown. One machine manufacturer is reported to have applied for patents for doing just this.

As an aside, the big packaging companies such as P & G, Lever Brothers and Colgate-Palmolive are also very much interested in vacuum forming developments; one company is so interested in this work they're funding an individual chemist who is near perfecting a process for orienting extruded sheet so that it can be formed into containers faster. Their goal: a material and a process to make formed containers for solid or powdered soap products. They ask, if you can make a cigarette pack, why not a soap suds box.

Another area in which we can look for dramatic developments is in new resin developments. The packaging industry would like to see a clear plastics. Most of their products move from clear or flint glass bottles, and they'd like to see them move to clear plastics bottles. Polyvinyl chloride (PVC) is often mentioned as a possibility. Because of its chemical resistance, PVC is particularly attractive as a means of developing new, large markets for packaging such products as cleaners, shampoos and cosmetics. Holding PVC back is price - estimated 10-25% higher than high density polyethylene. The cost is higher because of PVC's greater gravity and the additives required to make it processable.

Another resin which is beginning to be a factor in blow molding is ABS. This resin will be finding an increasing number of applications in the non-container market, apparently because of two factors: (1) ABS has better resistance to certain industrial and automotive environments such as hydrocarbons, lubricating oils, waxes and Freons -- important for aerosols, and (2) some blow molders now find themselves with available machine time and are awakening to the processing potentialities of blow molding non-container items.

Polycarbonate is now being mentioned as a possibility, too. Blow molders in Europe are getting around the resin's high cost by going to extremely thin wall sections -- possible because of the rigidity and high impact resistance of polycarbonates. Another interesting possibility is a polypropylene resin which gives the optical illusion of being transparent when a liquid of a certain color and density is placed in the container. The illusion is partly created by very thin wall sections and highly polished molds. Continental Can's clear polyethylene resin also has the big packagers very excited.

Acetals are another group of resins slated for big things in blow molding. Developmental work is going on presently to produce blow molded acetal aerosol bottles. Present packages which will be feeling this competition are aerosol cans and plastisol-coated glass bottles.

Another technical area in which we can expect further developments, and soon, is in labelling. The large users think it's ridiculous to put a paper label on a plastics bottle. And so, unquestionably, there will be acceleration of effort to come up with an economical process for supplying decorated bottles. Already, Continental Can's dry-offset printing method has moved from the technical center into bottle production plants. But, remember what was said about coming developments in machinery which will permit a machine to produce a finished bottle. This concept will also probably be applied in producing bottles which have been labelled in the mold. Union Carbide is said to have one of the most interesting processes, in this respect, with a plastics label being applied right in the mold. Samples are reported to be glossy and permanent, but industry acceptance in general will lag until the

price becomes competitive with applying paper labels. Another interesting development in decorating bottles is the electrostatic printing process developed by Stanford Research Institute.

Finally, in the area of standards, there is a definite trend on the part of the buyer of plastics bottles to specify tighter tolerances - both dimensionally and material specifications. There are some complaints among bottle buyers that bottle finishes are anything but standard now. And while they, themselves, are probably the most blameful by insisting on special designs or shapes, they still would be happier in the long run if the bottle manufacturers got together and established standard finishes, forced then to use them, just as The Glass Container Manufacturer's Institute has done with glass.

The possibility of marketing carbonated beverages in plastics containers is, of course, an intriguing one. This is a huge volume market and a number of companies are studying ways to improve the permeability of blow-moldable thermoplastics. Some research is oriented in the direction of relating degree of crystallinity to permeability. Other more practical engineering approaches are also being contemplated such as dual extrusion of two different materials, with one of the two materials forming the barrier to the gases, and coating the inside of a plastics bottle with a material which would decrease the permeability of the package. However, in spite of work that is progressing, a non-permeable resin for carbonated beverages is probably not just around the corner.

MARKET PATTERNS

All of the present big users of plastics bottles have more products on the shelf or in their laboratories which they want to see in plastics bottles. As a matter of fact, Lever Brothers' concept of packaging is that you first develop the package, then the research lab can come up with any product to put into it. For instance, a very beautiful bottle having the shape of a woman on which a dreamy dress is draped was developed for Lever Brothers. Then the product - a laundry rinse called "Final Touch" was perfected to go into the bottle.

Similarly, most heavy-duty detergents are marketed as solids. Big, new markets for plastics bottles will open up when the solid heavy-duty detergents are reformulated to liquid for packaging in bottles. Studies by Lever Brothers have shown that pint polyethylene bottles occupy half the shelf space of regular powder detergent packs and provide 50% more profit per package.

It might be mentioned at this point also that while there are seven or eight very large blow molders supplying the very large users, there appears to be plenty of room for smaller blow molders to supply bottles for regional markets, for example, private label detergents for small and medium size chains.

Other large markets which are under active consideration for plastics bottles include oil cans, starch, household cleaners, vinegar, catsup and mustard.

Another market pattern which seems to be developing rapidly and which portends big volume is the "stock" bottle. Half-gallon, non-returnable, blow-molded stock polyethylene bottles are being used by dairies. Dow has recently announced the first stock half-gallon polyethylene bottle for fruit drinks. The new containers are designed with a slightly off-centered wide mouth and pouring lip to avoid any possible design identification with plastics bottles used for non-food products such as bleach.

The cleanser container business also is a nice healthy market for blow molded containers. Purex was first with a vacuum-formed container for Old Dutch. However, troubles developed and they have joined both Lever Brothers and Colgate in going to blow molded containers. The business is estimated to be about 350 million containers per year. This is just another example of what was stated earlier -- the bottle users have nowhere near run out of products to put into plastics bottles.

Affecting market pattersn, of course, is price. And as happens in all sectors of marketing in the plastics industry, the end-users use many devices and even clubs, if you will, to control resin prices. One large end-user, for instance, is said to ask for quotations based not only on bottle price but also the toll charge for conversion if they - the end user - supply the resin. Experience in talking with the various large end-users of plastics bottles also shows an amazing candidness in predicting where the bottom is for high-density polyethylene. For instance, executives of one end-user company have such complete costs on elements such as price of ethylene, polymerization plant construction and economics, built-in profit margin, and processing economics, that they are positive that 8 to 10 cents per pound must yet come out of the price of high-density polyethylene. They say it won't happen overnight, but nevertheless it will happen, say within five years.

While the spotlight is currently on blowing bottles, the non-container market, is thought by some to be just as large. For instance, one estimate shows the market for blow molding resins to be 350 million for 1963, with 100 million pounds going into non-containers. By 1960, this same source estimates the total blow molding resin market to be a billion pounds, split evenly between containers and non-containers.

COMPANY INTEGRATION PATTERNS

There is a well-established trend towards integration into processing on the part of resin manufacturers. Integrated producers include Celanese, Dow, Monsanto, U.S.I. and Union Carbide Plastics. Phillips might be considered to be partially integrated, though in vacuum forming machinery, through its stock purchase in Purex, along which came a 50% interest in Purex's Brown Machinery subsidiary.

One reason behind this pattern is the fact that you have to be big to do business with the Procter & Gambles and the Lever Brothers. The raw materials suppliers are in a position to enter the business on a large scale and are able to provide the demanding services of very large users of plastics bottles. While such companies as P & G and other large users may purchase a few bottles from a small processor, in the words of a purchasing agent for volume quantities of bottles, "We'd bleed him to death in six months".

Whether or not the resin producers are right in integrating into processing remains to be seen. If they're making money now and can pay off this investment in not too many years, it appears to be a sound move. However, too many integrated producers say blow molding is not now an especially profitable business - that the profits will come when other markets open. Maybe. But that's when the large end-users might consider captive processing an attractive investment. Some of the large end-user companies are quite frank in admitting the only reason they're not in processing now is that the equipment is in such a state of evolution, they're afraid they might get caught with a battery of machines which have been obsoleted overnight. When blow molding equipment becomes more sophisticated, more automatic, and faster, look for wholesale captive processing to begin. Even if the statement is made today "Our business is making soap, not bottles".

About the Author........

Melvyn A. Kohudic is Editor of the Society of Plastics Engineers' publications. He is Founding Editor of the Society's newest publication, SPE TRANSACTIONS.

Before joining the SPE in Stamford, he was, for three years, Associate Editor of Industrial and Engineering Chemistry, a publication of the American Chemical Society.

He is a 1953 graduate of Penn State University with a B.S. degree in chemistry. After graduation from college, his first assignment was with the Armstrong Cork Company in Lancaster, Pa., as a research chemist for over three years. His work at Armstrong was concerned with developing new injection and compression molded products.

Introduction at Luncheon -

Armand G. Winfield
President, Western New England Section

Crystopal, Ltd.
Hazardville, Conn.

On behalf of the Western New England Section of SPE, we wish to welcome our distinguished guests and honored friends to this RETEC, "Blow Molding - Progress Report".

Of all of the technological advances in the field of modern plastics, probably among the most significant is the phenomenal growth of the blow molding industry.

Nowhere else in plastics history has a new technique grown as fast, as far reaching or with such an economical punch as this field. Its far reaching effects have increased the sales of new machines and have opened new markets for the raw material supplier as well as for the converter and the consumer.

As this process continues to grow, the ever increasing storehouse of data is being accumulated and disseminated in all parts of the world.

The Western New England Section chose to sponsor this RETEC in order to pause, review and summarize the blow molding field ... to indicate what has been accomplished, to point out what is now being done and ultimately what is being planned for its future growth and development.

During the first session this morning, you heard a series of speakers individually dealing with new developments and trends in blow molding. This afternoon, you will hear two provocative three-member panels with even more phases of this industry and following the panels, there will be two additional papers - the final one being an analysis of what our European counterparts are presenting and predicting in this field.

During the luncheon program we are going to take a short excursion from blow molding to explore two timely subjects - SPE engineering progress and a most informative evaluation of Soviet impressions of American science presented by a U.S.I.A. specialist.

It is our hope that all of you present at this RETEC will have absorbed data pertinent to your particular interest-phase of the industry, and that you carry away with you a feeling of satisfaction of a day well spent.

About the Author........

Armand G. Winfield, Executive Vice-President of Crystopal, Ltd., Hazardville, Connecticut, has been in the plastics field for almost 25 years. From 1957 to 1963 he has been a plastics consulting engineer for DeBell and Richardson, Inc., of Hazardville, Connecticut. Previously,

he has been affiliated with the Hanley Plastics Company, Division of the Wallace Pencil Company of St. Louis (Research Director, 1955-1957), Seymour Wallas and Company, St. Louis (Advertising Manager), the Rite-point Company, St. Louis (Plastics Product Design Engineer), and Winfield Fine Art in Jewelry, New York (General Manager).

Mr. Winfield received his B.S. degree from Franklin and Marshall College in 1941. Since then, he has been on the Chemical Engineering Faculty of Washington University (1956) and more recently has been a guest lecturer on plastics at Yale University (1960-1961).

Mr. Winfield has been extensively published in the plastics field and has authored "Plastics for Architects, Artists and Interior Designers" (published by SPE, 1960), and a second book is to be published by Rheinhold in 1964.

In January, 1960, he was asked to serve on the SPI International Subcommittee to advise the United States Information Agency in the preparation of an exhibition of plastics which was to tour the U.S.S.R. as part of the Intercultural Exchange Treaty of November, 1959. In addition to aiding in the preparation of the exhibiting, he trained the staff in plastics technology, and co-authored with Henry M. Richardson the booklet on plastics which was distributed to the Soviets attending the exhibit. He also received a State Department American Specialist Grant in 1961, and accompanied the USIA exhibition, "Plastics - U.S.A." as Specialist-Consultant throughout its four month tour in the U.S.S.R.

Mr. Winfield is active in SPE. He is 1963-1964 President of the Western New England Section, had been Chairman of the Plastics In Buildings PAG for three years. He is also active in BRI (Building Research Institute), is on its Planning Committee on Plastics in Building and on the Planning Committee on International Building Research Liaison.

Luncheon Program Moderator -

William O. Bracken
Manager of Packaging Development

Hercules Powder Company
Wilmington, Delaware

William Owen Bracken was born in Boston, Massachusetts in 1913 and attended schools there. He received his B.S. degree in chemical engineering from Tufts College in 1936.

Joining Hercules in 1939 as a chemist at the company's Research Center near Wilmington, Mr. Bracken transferred a few months later to Hercules' Parlin, New Jersey plant, and in 1945 was assigned to the Home Office, in Wilmington, as a member of the Plastics Marketing Section of the Cellulose Products Department (since April, 1961, known as the Polymers Department).

In 1946 he became Assistant Product Supervisor of cellulose acetate, moving into plastics technical service work the next year. Between the years 1947 and 1952, Mr. Bracken worked in the development group of that department, finding new uses for Hercules plastics for both industry and the military. From 1952 to 1955 he was associated with the development work of nitrocellulose coatings in such fields as transportation and the military.

In 1955 he became a member of the Hi-fax sales group, and in December, 1957, a member of the Plastics Sales Development Group. He was named Supervisor of Market Development in July, 1962, and assumed his present assignment in October, 1962.

Mr. Bracken is a Past President, Vice President and Councilman-at-Large of the Society of the Plastics Engineers, and Past President of the Philadelphia Section of SPE (he is also Past Chairman of the Blow Molding Professional Activity Group and Chairman of the International Plastics Engineering Award Canvassing Committee).

He also is a member of the American Ordnance Association (member of Plastics Committee, Materials Division); Society of the Plastics Industry; Society of Automotive Engineers, and Alpha Tau Omega Fraternity. Mr. Bracken currently is Chairman and has been Vice Chairman and Chairman-elect of the Division of Organic Coatings and Plastics Chemistry of the American Chemical Society, member of the Advisory Committee for several years, and Symposia Chairman.

"PAGs - THE TECHNICAL ARM OF SPE"

Guy A. Martinelli

SPE Vice President, Engineering

President

Dimensional Pigments, Inc.

Bayonne, New Jersey

About the Speaker........

Guy a Martinelli, SPE Vice President, Engineering, for 1963, is President of Dimensional Pigments, Inc. of Bayonne, New Jersey. Before joining this company in 1961, he was associated with American Viscose Corp. for fifteen years, of which five were as Sales Manager of the Plastics Division. He was also on the staff of Calavo, Inc. prior to military service.

During five years in the Army Signal Corps in World War II, Mr. Martinelli rose from private to Major, serving two years in the Far East.

He attended LaSalle and New York Universities.

Mr. Martinelli has long been active in SPE affairs and is a past Secretary and President of the New York Section. He was General Chairman of the SPE Annual Technical Conference in 1959 and Chairman of the Meetings Committee in 1960. During 1962 he served as Chairman of SPE PAG Executive Committee, and was responsible for administration of the Society's 18 Professional Activity Groups.

In his role as Vice President, Engineering, Mr. Martinelli directs all technical activities of the 10,000 member international engineering society including publications, meetings, education and professional activity.

Mr. Martinelli resides in Red Bank, N. J. where he is active in civic, church and PTA affairs.

"SOVIET IMPRESSIONS OF AMERICAN SCIENCE"

Dr. Paul R. Conroy
Chief, Professional Training

United States Information Agency
Washington, D. C.

About the Speaker.......

Dr. Paul R. Conroy is responsible for training the foreign service officers going into the Soviet Union and through this association has an opportunity to interview these people upon their return to the United States. From his firsthand information he is able to compile an accurate picture of Soviet views on American science and life.

Dr. Conroy was born January 16, 1912 at Java Center, New York. He attended Canisius College in Buffalo (B.S., 1931) and Fordham University, Fordham, New York (M.A., 1932).

After teaching at Canisius College, 1933-35, he received a teaching fellowship at St. Louis University and received his PhD. from that institution in 1937, with a major in U. S. History. From 1937 to 1944 he served as Professor of History at Canisius College, including direction from 1942 to 1944 at Basic Indoctrination Instruction in the Army Air Force pre-flight program at the college. In 1944 he joined the Curtiss-Wright Corporation, Airplane Division, in the field of management and supervision training and, for two years, conducted management conferences for Curtiss-Wright executives.

After the war, Dr. Conroy entered government service with the Veterans Administration, serving first as Chief of Advisement and Counseling Service for New York State, and later directed all contract negotiations with schools of all types for the provision of educational services under the G.I. Bill of Rights, and to disabled veterans under special legislation providing for rehabilitation training.

In 1949, Dr. Conroy returned to academic work and served as Professor of History at Seton Hall University, South Orange, New Jersey, until 1952 when he joined the Department of State as personnel training officer for the Voice of America in New York.

In 1953, the United States Information Agency was established by executive order of the President to take over and operate all foreign information programs of the United States. Dr. Conroy became an employee of the new agency at that time. In 1954, he was appointed to his present position of Chief of the Professional Training School of the Agency.

He is responsible for the planning and conducting of the Agency's Training Program for its foreign service officers, with special attention to the development of the knowledge and skills required in doing a good

job of representing the United States overseas. Under Dr. Conroy's direction, intensive training is given in problems in interpreting American civilization to foreign audiences, studies in communist theory, tactics and practice, and in techniques of communications and propaganda. Dr. Conroy participated in the training of guides for the American Pavilion in Brussels in 1958 and for the American National Exhibition in Moscow in 1959.

Dr. Conroy trained the American guide staff for five U. S. exhibits in the U.S.S.R. during 1961-63: (1) Plastics, (2) Transportation, (3) Medicine, (4) Technical Books, the latter scheduled to complete its showing in Khiev in June, 1963, and (5) Graphic Arts, opening in September, 1963.

Afternoon Session Moderator -

Robert E. Dunham
Supervisor, Material Development

Plastics Products Division
Owens-Illinois
Toledo, Ohio

Robert Dunham received his B.S. from the University of Toledo in 1938 and did graduate studies at both the University of Toledo and at Purdue University.

After one year with the Drackett Company, Mr. Dunham has completed 23 years in research, development and engineering with Owens-Illinois. He has worked in a variety of plastics materials and processes and has been affiliated with blow molding for 15 years - though he made his initial sortie into blow molding in 1940.

He has held many positions at Owens-Illinois, working his way up from material testing through quality control, from Plastics Laboratory Supervisor to his present position as Supervisor, Material Development.

Mr. Dunham has been a member of the American Chemical Society for the past 25 years. He is a Director of the Toledo Section of the American Society for Quality Control. In SPE, he is a Past President and Charter Member of the Toledo Section, a Councilman, and more recently, Chairman of the Blow Molding PAG in 1962.

IN-PLANT PRODUCTION OF PLASTICS CONTAINERS

Joseph Y. Resnick

President

and

William A. Jacobs

Technical Director

Questron America, Inc.

Ellenville, N. Y.

Up until World War II all containers for consumer products were made from metal or glass, with waxed coated paper used for milk and fruit juices.

The big turn to plastics containers came in the late fifties with the increasing availability of polyethylene. Other plastics became available adding to the growing use of plastics containers, although polyethylene remained the most important resin used for containers. Over the years the price of polyethylene continued to drop making it economically feasible for more and more packaging applications. As the number of companies manufacturing polyethylene increased, so did the grades and varieties. At the present time a user of polyethylene can choose from over 1000 different types and grades. As the reliability of the resins increased, the difficulty of processing them decreased, permitting firms with little or no experience in plastics processing to consider making their own containers.

Until recently packaging of all types was purchased from converters. These converters would purchase paper, metal or plastics; fabricate, decorate and ship the finished packages to the ultimate user. With few exceptions, such as American Can and Continental Can, these converters were essentially small firms performing a service. The use of plastics containers continued to increase at a tremendous pace and the number of units required by the end user grew even faster. Suddenly the large national packers, particularly in the soap, household chemical and cosmetic industries, found themselves purchasing tremendous quantities of a given container. This concentration of volume made the in-plant production of plastics containers practical.

While some large food packers have operated their own facilities for making cans or paper packages, the capital investment and technology required limited this activity to just a very few. However, as the capital cost for plastics container manufacturing equipment (per 1000 containers) is relatively inexpensive, more and more firms showed interest in making their own.

By 1961 plastics bottles virtually eliminated glass and metal containers from the bleach and detergent market, even though plastics was more expensive than glass or metal. Bleach and detergent packers began to realize that any significant saving they could make would be in the cost of the container, as the product was so inexpensive. A case in point is the Purex Corporation of Los Angeles, California. While they and a few other detergent manufacturers successfully learned to manufacture their own plastics containers, a great many others were discouraged because of the lack of equipment designed to do this job.

It was the original intention of Questron to manufacture plastics bottles and merchandise low cost, private label, beauty items such as shampoo and handcream. A suitable machine could not be found, so one was designed and built by the company. This resulted in JYRAK, a trademark for a system designed specifically to manufacture plastics containers in-plant. The basic aim was to produce a system that was reliable, easy to operate and maintain, and to produce plastics containers at low costs. In order to reach these goals a radical departure from the accepted principles then in use was necessary.

First, a vertical extruder was developed rather than use the standard horizontal one. This vertical extruder had many advantages, one of the most important being the elimination of the crosshead extrusion die. A crosshead die always required design compromise. The end result makes it difficult to extrude a symmetrical parison under equal pressure. The vertical extruder permitted use of a straight through extrusion die that is approximately 1/3 the size of a standard crosshead. It produces a balanced symmetrical parison, is extremely simple to adjust and can be changed in fifteen minutes. As a result thin walled, light weight containers can be produced with a minimum of rejects. The weight differential between bottles is held to less than 5%.

The small straight through die eliminated "hang-up areas" and it is possible to extrude (and blow) such difficult resins as rigid PVC, polypropylene, styrene and Lexan (polycarbonate). As there is much less die area, color and resin changes became a matter of minutes rather than hours.

By designing the instrument console into the main frame the operation of the equipment was simplified and a significant amount of space saved. JYRAK systems require approximately 1/3 the space used by horizontal equipment and weigh 60% less.

Commercial equipment available prior to JYRAK, either separately or in combination, had moving molds, accumulators or multihead extrusion dies. As each of these systems had certain intrinsic disadvantages, a number of methods that would eliminate these problems were investigated. It was determined that the simplest, most positive method was to move the parison by a simple finger mechanism, alternately to the molds. Thus many moving parts, check valves, hydraulic pumps, two axis mechanisms and large complicated extrusion dies and heads were eliminated. Aside from the many mechanical advantages it was also possible to blow the container from the top. This resulted in proper weight distribution and eliminated pinch-off from the neck. In addition, the bottom of the parison could be sealed before moving it into the mold, thus eliminating the tail. The completely finished bottom permitted

the use of another finger mechanism which removed the finished container from the mold, placing it onto a conveyor. The conveyor then moves the container to an automatic trimming, and (if necessary) reaming station.

This is the essence of any in-plant container manufacturing system; the delivery of completely finished containers directly onto conveyors without the use of hand labor. The container can then be accumulated to run through a conventional high speed line. Table I shows the savings that can result from the in-plant manufacture of plastics containers. It is believed that these figures substantiate the premise that the least inexpensive container is the one made in-plant from plastics.

Beyond the in-plant manufacturing concept is the in-plant in-line concept which is the ultimate in efficiency, speed and quality. Before the end of the year, this system should be in operation in Ellenville. From the trimming station the container will be fed to a special flexographic printer. The bottle is dry as it leaves the printer and is delivered to a conveyor that takes it to an inexpensive low speed filler and capper. Thus, any given product can be packaged completely, automatically in-line virtually untouched by human hands. On an in-plant in-line basis, all the necessary equipment is paid for in less than a year.

Too often, packaging engineers tend to think in terms of units per minute rather than ultimate cost per thousand. It is our firm opinion that plastics containers can be printed, filled and capped with the same labor required to make the container. Further, because of the basic economies, plastics containers will not only prove cheaper than glass or metal but less expensive than paper as well. Already a quart container that a dairy or oil refinery can produce for $25-28 per thousand has been developed.

About the Authors........

Joseph Y. Resnick is 39 years of age. He graduated from Ellenville, New York High School and served as a Radio Officer in the Merchant Marine for 2-1/2 years.

Professionally, he has been a Television Engineer at Dumont Broadcasting; Founder and Chairman of the Board of Channel Master Corporation, Ellenville, N. Y.; President of Dyna-Foam Corp., Ellenville, N.Y.; and more recently, President of Questron America, Inc.

William A. Jacobs, 41, received his degree from Ohio University and served as a B-26 Air Force Pilot for 3-1/2 years in World War II. Prior to the war, he was with Grumman Aircraft and after the war he was first with Standard Brands, Inc. as Staff Assistant in Purchasing and Traffic. Later he became Research and Development Director of Trans-Gel Products, Inc.

His next venture was a proprietary woodworking business based on unusual techniques he developed with wood. This was followed by a stay at Wrapture, Inc., a flexographic film printing and conversion plant, where he was Production Manager.

More recently, Jacobs was Technical Director and General Manager of the Dyna-Foam Div. of the Sun Chemical Corp. where he developed and perfected a process for extruding and part-forming and fabricating expandable polystyrene.

Currently, he is Technical Director of Questron America, Inc.

TABLE I

IN PLANT PRODUCTION COSTS PER 1000 CONTAINERS, BASED ON

4000 OPERATING HOURS PER YEAR

EQUIPMENT DEPRECIATION CHARGES BASED ON A THREE YEAR WRITE-OFF

Size, ozs.	Annual Container Production	Depreciation Cost/M,$
2	4,800,000	2.00
4	4,400,000	2.25
6	4,000,000	2.50
10	3,200,000	3.75
16	2,400,000	5.00
32	1,800,000	7.50

RESIN COSTS BASED ON LINEAR POLYETHYLENE @ $.25/LB.

Size, ozs.	Gram Weight	Lbs. of Resin	Costs/M,$
2	8	18	4.40
4	12	27	6.60
6	16	35	8.80
10	24	53	13.20
16	34	75	18.70
32	52	115	28.60

LABOR, MAINTENANCE AND OVERHEAD CHARGES BASED ON $3.00 PER MACHINE HOUR

Size, ozs.	Container Production/Hr.	Cost of Labor/M,$
2	1200	2.50
4	1100	2.80
6	1000	3.00
10	800	3.40
16	600	5.00
32	450	6.65

ESTIMATE OF SAVINGS PER 1000 BOTTLES (UNPRINTED)

Size, ozs.	Estimated Market Price,$	Total In-Plant Costs, $	Net Savings,$	Savings Over Purchase Price,%
2	25.00	8.90	16.10	64
4	30.00	11.65	18.35	62
6	34.00	14.30	19.70	59
10	42.00	20.35	21.65	51
16	52.00	28.70	23.30	45
32	75.00	42.75	34.25	46

PARISON PROGRAMMING FOR BLOW MOLDING

Lloyd Kovacs

Development Engineer

Research and Development Department

Waldron-Hartig Division,

Midland-Ross Corporation

Westfield, New Jersey

It is a well known fact in blow molding that the ultimate thickness of a point in the product will be related to the wall thickness of the parison. If we start with a parison having relatively uniform longitudinal cross section, should we strive to make a product other than cylindrical, we should expect to have a longitudinal variation of wall thickness in the blow molded part. Many times we will find that the overall weight of the part must be increased in order to meet minimum wall thickness requirements. As a result of this problem, and since parts cost can be directly related to the dimension control of the finished product - a great amount of interest had been displayed toward the development of programmed parison extrusion. Utilizing parison programming methods, the molder is now able to vary the wall thickness of the parison as it is being extruded, thus anticipating the final shape of the product in terms of parison wall thickness. This, of course, opens up new vistas in blow molding. Existing parts can be molded with reduced weight as well as new shapes which heretofore did not adapt themselves to blow molding.

There are two basic approaches to parison programming. One is based on the extrusion rate of the parison, the other on varying the extrusion orifice.

It can be shown that the weight of a blown item varies directly with the rate of extrusion (Fig. 1). This relationship can further be traced to the swelling of the parison during extrusion. The amount of swelling is a characteristic of viscoelastic materials, but for a particular resin there are a number of variables which will effect swelling; the most important being pressure and temperature. Pressure or output rate is of prime importance for our consideration. Swelling turns out to be a constant volume effect; that is, as the parison is extruded, a three dimensional change takes place resulting in reduction of the length of the parison. Since swelling is some function of pressure this fact is often utilized by molders to make minor changes in part weight by changing the rate of material flow through the die. It can be seen that this first technique cannot be applied to machines utilizing the straight extrusion principal, since only a small amount of change can be effected on the parison. Sudden changing of extruder speed during parison extrusion is not practical.

We are all familiar with parison "sag" or "draw down". How long a parison can be extruded before "draw down" becomes excessive is mainly a function of the rheology of the thermoplastic used. There is a limit to the weight of material

that can hang in space before breaking.

The problem of "draw down" as well as excessive exposure of the parison during extrusion prompted the development of the ram accumulator type of blow molding machine. This type of machine insures fast parison delivery independent of extruder plasticizing rate, thus the ram accumulator type of machine can readily be adapted to parison programming by varying the parison delivery rate. Varying delivery rate can in turn be applied to reducing part wall thickness variations due to parison draw down (Fig. 2).

Modern up to date blow molding machines normally are supplied with ram accumulators. Most machines use a ram to discharge plasticized material from a shooting cylinder and usually a hydraulic cylinder to power the ram, and the necessary hydraulic power unit to supply the required pressure to the ram.

The amount of power required to be delivered to the ram accumulator is large, but since this power is only required for a small portion of the overall cycle, the use of a small hydraulic pump and hydraulic accumulator is ideal. The hydraulic accumulator is charged up to a predetermined level during the cooling cycle and is discharged during the parison delivery cycle. As oil is used up from the accumulator a drop of pressure is experienced. A parison delivered from earlier ram accumulator type machines had a characteristic shape, being anything but uniform all the way through. The problem of non-uniform parison was solved by the placement of a pressure compensated flow control valve into the ram accumulator hydraulic circuitry. This valve has the property of maintaining constant flow irregardless of up or downstream pressure variations. The next step was to make this valve cam operated, tying it in directly with the motion of the ram. The shape of the cam would now determine the approximate shape of the emerging parison (Fig. 3).

The advantages of hydraulic programming - or as I have been referring to as varying the extrusion rate of the parison, are many fold and include constant parison delivery over a wide range, variable parison delivery, usable with any type or size die and applicable to existing ram accumulator type machines without work on dies.

A. Constant parison delivery over a wide range is answered with this system. This is an important consideration especially when a new part is to be molded. It is not necessary to hit die bushing and pin dimensions "on the nose"; an approximation will suffice. After the die is installed, a part is molded and checked for overall weight. The weight of the molded part can now be changed about 40% without seriously changing the overall cycle time. This is accomplished by the setting of the hydraulic flow control valve. There will be some sacrifice in parison delivery time with this method, but it is more than offset by part uniformity.

B. Variable parison delivery is accomplished by the use of a shaped cam. The rate of change will be determined by the shape of the cam which in turn changes the flow control setting. The flow control in turn modifies the hydraulic cylinder motion thus moving at a speed commanded by the flow control valve. The new action is similar to a planer where the carriage speed stays constant as the tool moves across the workpiece.

C. Hydraulic parison programming can be applied to any type or size die. Since the programming is hydraulic, the die does not need additional work when going from unprogrammed to programmed extrusion. On many

occasions the fact that parison delivery rate is fully adjustable independent of extruder plasticizing rate can be used to overcome deficiencies in die design. Should melt fracture present itself at a particular parison delivery rate, it is only necessary to reduce the rate until the condition is eliminated.

Parison diameters are constantly going up as larger and larger shapes are molded. The problem of programming a parison 14" in diameter is not an easy one. Hydraulic programming offers one relatively simple method of accomplishing this objective.

D. Hydraulic parison programming can be applied to existing ram accumulator blow molding installations with a minimum amount of effort. The installation of cam operated flow control valve with the cam support mechanism is all that is necessary for hydraulic parison programming.

There are, of course, certain limitations to hydraulic parison programming which should not be overlooked. These are, programming can be applied to ram accumulator or reciprocating screw machines only, the amount and number of changes are limited and types of resins that can be programmed in this portion are limited.

1. The fact that hydraulic parison programming can only be applied to ram/accumulator or reciprocating screw blow molding machines is not necessarily a limiting condition, since most of the larger and longer blow molded objects are produced with either of the above mentioned methods.

2. The amount and number of changes that can be effected with hydraulic parison programming is limited, the limiting factors having to do with die design as well as melt rheology. A high acceleration is necessary in order to force material through an orifice at a high rate. A high stress in turn develops in the melt producing a highly elastic melt deformation. This simply means that there is a definite time lag between the time the change is applied and the change in parison dimensions actually takes place. The reverse effect takes place when the flow is changed from high to low rate. As a consequence, sharp and sudden change in parison dimensions are difficult if not impossible to achieve. The relaxation time of most blow molding grade low and high density polyethylene is much longer than the time available for parison delivery, consequently the parison keeps changing dimensions after delivery from the die. This can most likely be attributed to the relaxing elastic strain that decays at a rate different from that of the stress which induced it.

   The amount of change that a parison can undergo will depend on die design and rheology. The apparent shear rate of the material can reach the critical point where melt fracture will take place. This condition is, of course, unacceptable for various reasons. Melt fracture can occur at relatively low flow rates with shear sensitive materials.

3. Since hydraulic programming depends on the swelling characteristic of the polymer, there is a limit as to the types of resins that can be used. In general, good results are obtained with low and

high density polyethylene and polypropylene. Tests conducted with nylon, polycarbonate, plasticized vinyls, vinyl plastisols and ABS indicated that the degree of swell is either nil or very small, not suitable for programming purposes. ABS tends to swell to some degree, but further investigation revealed that the small amount of moisture in the resin was responsible for the swelling. This, of course, is ture of all hygroscopic materials. Tests with styrene showed inconclusive results.

With the above in mind, a second method of parison programming has been evolved which involves moving of the die mandrel concentric with the die ring, thereby actually effecting a change in die orifice size. Various methods are employed in moving the mandrel. One method involves the use of a lever arm in conjunction with an air or hydraulic cylinder supplying the power. This method has one drawback in that the rate of change is controlled by flow control valves, thus more than one rate of change during a cycle is hard to achieve. Another method involves the use of a power cam. With this method the shape of the cam determines the rate of parison change. A hydraulic cylinder powering this cam is moved through its stroke, raising or lowering the die mandrel in accordance with the shape of the cam. The cylinder completes it stroke when the correct length of parison is reached. This method offers, for all practical cases, an infinitely variable rate change. One serious drawback of this method is that shaping of the cam becomes a milling operation, thus setup time as well as shaping of cams of different profile becomes a tedious operation.

Still another method involves the use of several switches in such a manner that as the parison is being formed, its wall thickness can be changed in predetermined increments. The objection to this system is the step change that takes place in the parison. This could be objectionable in some cases.

The parison programming about to be described utilizes a power cam for mandrel motion with one basic difference. The power cam has a constant taper such that the full stroke of the hydraulic cylinder represents the total excursion of the die mandrel; that is to say - the cylinder rod position is proportional to the die orifice cross sectional area. In conjunction with the power cam hydraulic cylinder a second synchronizing cylinder is used. This cylinder carries a template which is shaped to produce the necessary wall thickness change in the parison. This template is of light gage sheet metal, facilitating easy profile change without the use of power tools. The power cam hydraulic valve is controlled by a four way hydraulic valve. The whole assembly is arranged in such a manner that a closed loop servo system results (Fig. 4).

The operation of the unit is as follows: The synchronizing cylinder (C) speed is adjusted so that it will complete its stroke at the same time the parison reaches its proper length. As the synchronizing cylinder proceeds through its cycle the template (F) - which is attached to it - modifies the spool position of the four way valve (A) which in turn directs oil to the power cam cylinder (D). By attaching the synchronizing cylinder and template to the mandrel assembly, the control loop is closed. The mandrel will move vertically either up or down, depending on the contour of the template. Two objectives are achieved with this system: first, the rate of wall thickness can be infinitely varied; second, by using a simple template fabricated of sheet metal setup time can be a bare minimum.

The primary advantage of parison programming by die orifice change hinges on that a fine, controlled change can be effected on small diameter parisons. With this system molded part dimension control can be optimized, relating the wall thickness of the product to actual strength requirements. Proper wall thickness

distribution will invariably result in a faster overall molding cycle time.

Early work in parison programming revealed a condition which is objectionable from the standpoint of uniformly oriented cooling stresses in the finished product. As the die mandrel moves from its minimum to maximum position a drop in extrusion pressure is experienced affecting the surface finish of the finished part as well as creating non-uniformly oriented cooling stresses.

The above occurrence can be predicted by the general conditions for fluid flow through a die:

$$Q = \frac{\Delta P}{K \eta} \tag{1}$$

where:

Q = Volumetric flow rate

ΔP = pressure drop across the die

η = fluid viscosity

K = resistance constant

The resistance constant K is a function of die configuration and for a tubular die is as follows:

$$K = \frac{12L}{Cmt^3} \tag{2}$$

where:

L = die land

Cm = mean circumference of die

t = wall thickness

We can see that extrusion head pressure is directly proportioned to volumetric flow rate, viscosity, die load; inversely proportional to the die mean circumference and the cube of die opening, or thickness. This is expressed through the relation:

$$\Delta P = \frac{12Q\eta L}{Cmt^3} \tag{3}$$

Die mandrel position will have a pronounced effect on the two inverse variables: die mean circumference and thickness.

The apparent linear relationship expressed by equation (1) would be represented by a straight line on a flow vs. pressure drop curve; however, due to viscosity, which varies, a nonlinear relation exists between pressure and output.

Resin viscosity, η, for a particular resin at a given temperature and molecular weight is not constant; depends on the rate of shear in the die area concerned. The expression for the rate of shear for a tubular die is as follows:

$$\text{Shear rate} = \frac{6Q}{t^2\,(Cm+t)} \tag{4}$$

The shear rate produced by the change of resin velocity due to die cross sectional area produces a change in shear stress, which can be determined utilizing die geometry and resin rheology.

One fact becomes evident; varying of the extrusion die cross sectional area produces a variable shear stress in the material.

As was pointed out earlier in the discussion, non-uniform cooling stresses are set up in the finished product when parison programming is affected, as a result of varying pressure drop across the die. A constant shear stress through the die should theoretically produce a molded part with uniform cooling stresses throughout. For using the apparent viscosity or flow curve method, for a tubing die the following relations hold:

$$\text{apparent shear rate} = \frac{6Q}{t^2\,(Cm+t)} \tag{4}$$

$$\text{and shear stress} = \frac{\Delta Pt}{2L} \tag{5}$$

Due to the small die mandrel vertical motion "L" is essentially constant; variation in "t" however is important. The conditions set by equation (5) suggest a straight line relationship between shear stress and die pressure drop. Linear variation of extrusion pressure during parison forming should result in constant shear stress as implied by equation (5).

The amount of pressure, therefore, shear stress, required to obtain a certain volumetric flow rate through a die has a number of components:

A. Viscous flow element

B. Amount of energy expanded in viscous heat generation

C. Amount of energy required to elastically deform the melt

D. Amount of energy required to compress the polymer

E. Kinetic energy required to accelerate the melt through the die.

In straight extrusion and bottle blowing, the amount of energy required to compress the polymer as well as the kinetic energy to accelerate the melt through the die can be neglected. The corrected shear stress including end effects would be:

$$\text{corrected shear stress} = \frac{\Delta P}{2(\frac{L}{r} + e)} \tag{6}$$

where "e" is the negative intercept of a straight line relating pressure and $\frac{L}{r}$ ratio of a capillary (r is the capillary radius), (Fig. 5).

Equation (6) boils down to:

$$\text{corrected shear stress} = \frac{\Delta Pt}{2L} + \frac{\Delta P}{e} \tag{7}$$

where $\frac{\Delta Pt}{2L}$ is the uncorrected shear stress

and $\frac{\Delta P}{e}$ is the shear stress due to end effects

The preceding analysis would suggest that there is no simple way to achieve constant shear stress with programmed parison extrusion, but by modifying the pressure drop across the die as the orifice size changes a relatively constant shear stress can be expected. The combined use of hydraulic and mandrel parison programming gives us this flexibility. Anyone seriously interested in studying melt flow in general, through blow molding dies in particular, should investigate the available equipment for this purpose.

Both types of parison programming that I have discussed have certain inherent advantages. Combining the two methods will enable one to mold products with extremely uniform cross sections as well as place the material to where it will do the most good. Truly, parison programming opens up the second stage in blow molding offering a much improved process compared to the early years of struggle that preceded this development.

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About the Author........

After graduation from high school, Lloyd Kovacs served two years in the U. S. Army as Chief Radar Mechanic. For the next two years, he attended day sessions at Rutgers University, New Brunswick, New Jersey, presently completing his degreein electrical engineering.

Mr. Kovacs has been employed by Waldron-Hartig Division, Midland-Ross Corporation for the past seven years, working in the field of designing electrical, hydraulic and pneumatic circuitry; and for the past five years has been active in all fields of blow molding. His present position is Development Engineer in the Research and Development Department.

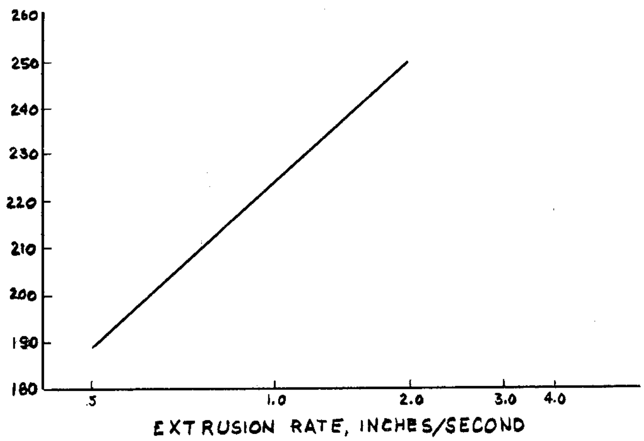

FIGURE 1

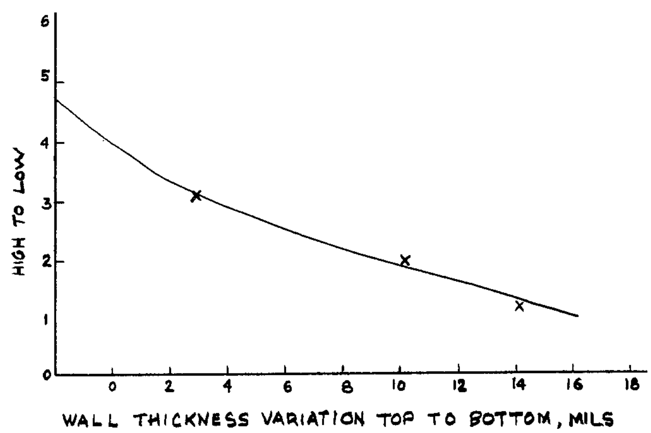

FIGURE 2

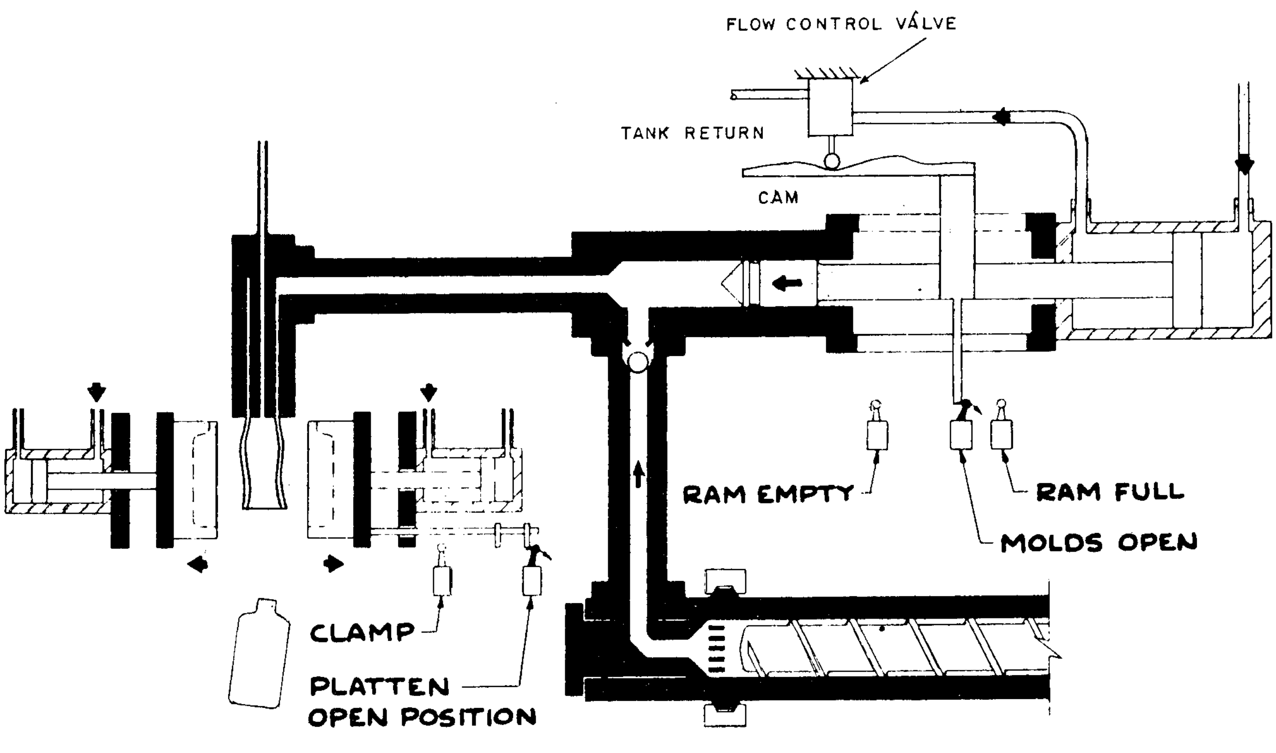

FIGURE 3

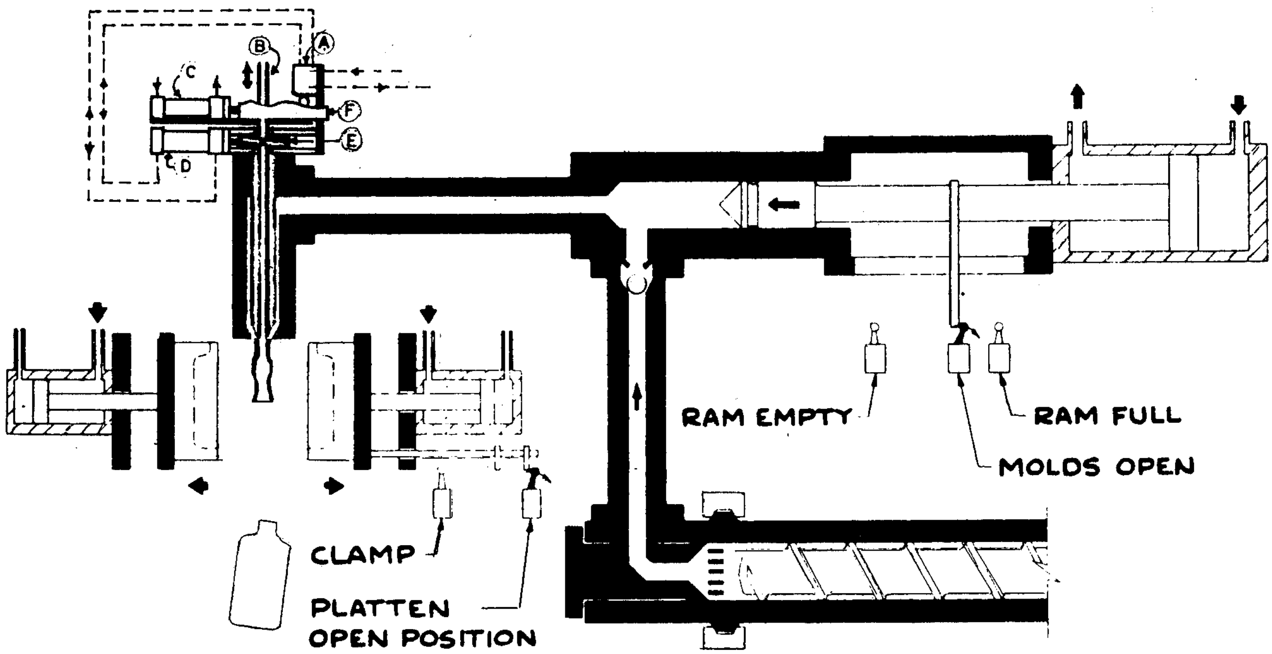

FIGURE 4

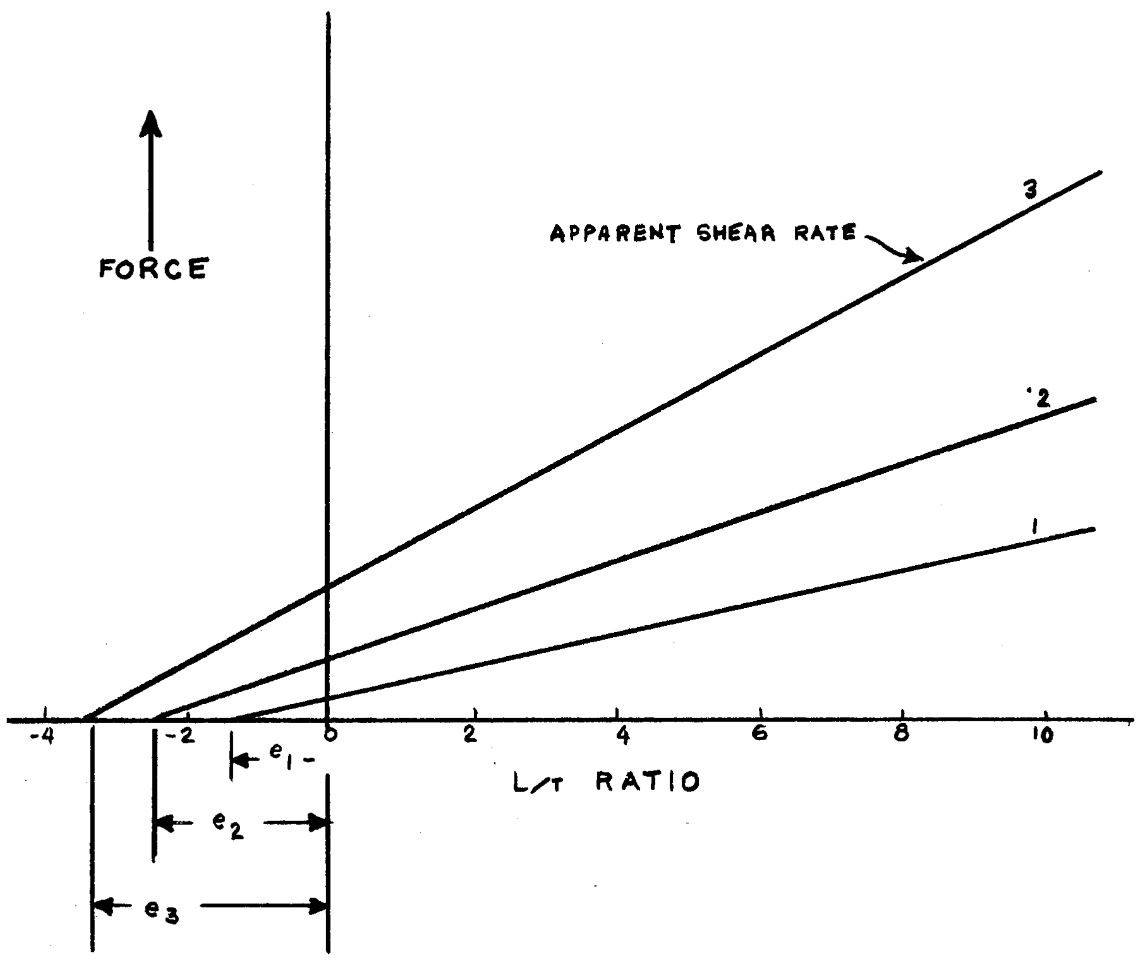

FIGURE 5: End Correction Factors at Constant Apparent Shear Rate

BLOW MOLDING INNOVATIONS

Dr. Edmund H. Merz

Director of Materials Research

Continental Can Company, Inc.

Chicago, Illinois

THIS PAPER HAS BEEN WAIVED IN FAVOR OF THE SPONTANEOUS PRESENTATION

About the Author........

Dr. Edmund H. Merz was graduated from the University of Michigan in 1944 with the degree of B.S.E. in Chemical Engineering. In 1945 he was awarded the M.S. degree and in 1957 the PhD. degree in Polymer Chemistry from the Polytechnic Institute of Brooklyn. He taught organic chemistry at St. Francis College, 1945-46, and physical chemistry at Brooklyn Polytechnic Institute, 1946-47. From 1947-1960 he was in the Research Department of the Plastics Division of the Monsanto Chemical Company. He is presently Director of Materials Research in the General Packaging Division of Continental Can Company. He has authored twenty-three technical papers and patents.

SPRAY DECORATING BLOW MOLDED BOTTLES

Elmer Faber

President

Deco Tools, Inc.

Toledo, Ohio

INTRODUCTION

Decorative effects can be economically achieved through the application of nickle electroformed spray masks, which offer the advantage of repetitive use through undreds of thousands of painting operations, due to their rigidity and accuracy of manufacture.

Nickle electroformed masks permit the spray application of colors to specific areas, obtaining sharp definition without subsequent buffing or wiping operations.

This type of mask is made by mounting an actual production piece part into a steel frame. After sensitizing for electrical conduction, they are electro-plated to obtain the desired thickness of metal required on the mask. After suitable reinforcing with wires, and any overhead bridging is applied, to support centers of letters, the production piece part is removed from the plated shell, and the decorative areas are cut out, using jewelers' saws with final filing for sharp definition. By utilizing the electro-forming method, an exact reproduction of the production part is obtained, which permits no overspray or leakage of paint to undesirable areas.

To better understand the various techniques of masking I would like to digress and go into the details of the various methods of masking in relation to their successful application. They are as follows:

A. Lip type mask for depressed letters or design, where the mask lips the lowered area and permits application of paint into the design.

B. Cap style mask where a raised letter or design is completely covered with an extending lip, permitting paint to be applied downward across the cap edge, producing sharp definition.

C. Block cut mask which permits filling of letters and design detail with less than 1/16" width of stroke on the letter. This type of mask requires a secondary wiping operation which leaves the entire letter or design filled with paint.

D. Plug style mask which is made primarily for keeping recessed letters free of paint while the background is sprayed. This type of masking requires extreme accuracy in molded parts.

By following the sequence listed above, and favoring them in the preference outlined, sharp and pronounced decorating can be achieved.

The cardinal rules-of-thumb to follow with reference to designing a blow molded or injection molded part for decorating is as follows:

> "Depress the area to be painted and apply a lip mask to the operation, or if multiple colors are to be applied, paint the highest surface, and then cap the first painted area to apply paint to the lower areas. Flame treating shrinks a blow-molded shape and the molder should supply properly flamed parts to the mask maker for preparation of masks."

For high volume production the nickel electroformed masks outlined above are applied to an automatic paint machine with production up to 1200 pieces per hour achieved.

The Imco Container Company produces 50,000 to 70,000 multiple colored bottles per day in each of five locations across the United States utilizing standard inexpensive machines and mask washers manufactured by Deco Tools, Inc. The basic machines are electric-driven, mechanically actuated stoking units with constant moving guns (88 strokes per minute) and foot pedal actuated, with air impulse control to eliminate the human element. Masks are washed in high pressure spray type mask washing machines which generate 20 psi and remove the paint from the masks at a rate of 20 wet coats in twenty seconds.

Two colors are applied by painting the first color on a machine, then placing the part on a conveyor traveling through an infrared type oven to the next machine where the operator applies the second color and again places part on the conveyor belt which continues through the second oven to the inspection and packing area. Oven temperatures are controlled by an input controller to maintain 125°F. temperature. Approximately two to two and one-half minutes are required in each oven which speeds of from 2 to 6 fpm produces. The number of parts produced on each mask vary from 18 to 70 depending upon the intricacy of the detail requiring paint, before washing.

It is our proven belief that painting machines should be of simple, sound fundamental design, with a minimum of wear surfaces and with complete flexibility to adapt to a wide range of parts. We have found through several years of experience that the fastest most accurate production is achieved through stroking type guns, as opposed to the oscillating type, and with constantly moving guns to avoid starting and stopping delays in the gun movement.

The best results in mask cleaning are achieved through a high pressure spray method, pump actuated with desirable pressures in the 20 psi range.

To illustrate several of our inexpensive standard machines we have prepared a series of slides with a sound tape which describes the features of each type of machine.

About the Author........

Elmer Faber, President of Deco Tools, Inc., Toledo Ohio, received his B.S. in Mechanical Engineering for Ohio Northern University and his M.S. from Columbia University.

Mr. Faber has been with several companies -- Chief Tool Engineer for Toledo Pipe Threading Machine Company, Director of Engineering, Ranson-Randolph, Chief Engineer, Conforming Matrix Corporation and Assistant Master Mechanic at Willys Overland.

Mr. Faber has a series of patents on his developments in the decorative fields including a pressure contact machine for decorative paint, an automatic paint and wash machine and a revolving gun mechanism for decorative painting. He also originated high pressure spray mask washers.

Elmer Faber is a past officer and Director of the Toledo Section of SPE and a Past Chairman of the Toledo Chapter of the A.S.I.M.E.

DECORATION OF POLYETHYLENE BLOWN WARE

Gene Krupinski

Sales Manager, Silk Screen Division

Sinclair and Valentine Co.

North Kansas City, Missouri

Polyethylene blown ware is decorated by paper labeling, therimage labeling, hot stamping, in labeling, dry offset, gravure offset and silk screen.

Recent advances in the silk screen process technique have increased its popularity for decorating polyethylene blown ware. We will describe briefly silk screen process printing and why it is used, polyethylene - the plastics, artwork for silk screen reproduction, the flame treatment of polyethylene, silk screen plates, silk screen printing equipment, ink systems and the static and dust problem.

Though we know some of the above listed headings are thoroughly understood by many, we feel a composite description of the total headings will be helpful in obtaining the best in silk screen decorated polyethylene blown ware.

Silk screen printing is printing through a plate whereas other media print from a plate. Gravure is printing from an etched cylinder. Letterpress is from raised type and offset from a surface plate or deep etch plate.

Silk screen process printing is the most versatile method of decorating polyethylene blown ware. One of the major advantages is that size and shape are no hindrance to a well decorated piece. The decorator can jig his silk screen press to the subject at a minimum initial cost. Silk screen printing leaves a heavy deposit of color with a choice of many ink systems. These include fluorescent inks, metallics (silver and gold), long oil alkyd, (a combination evaporative and oxidizing quick setting alkyd), lacquers and two pot epoxy resins.

Polyethylene bottle users package and display their products in these same decorated containers. The use of silk screen printing results in a colorful, bright, neat and attractive package. Where product resistance is a major factor, silk screen process fills the bill. The silk screen process plates and presses are made, and are made-ready quickly; this makes short runs economically feasible. Silk screen printing may be done to coincide with bottle manufacturing and filling schedules, thus keeping warehouse and production expenses down.

Initially, blow molding was confined to parts such as the squeeze bottle. Today, new materials have been utilized to make possible a variety of applications. Parts which range in size from 5cc ampules to 55 gallon drums can be produced and are being produced.

Artwork for silk screen process reproduction should be prepared with the following in mind. Design and copy should never be closer than 1/4" from a bottle

shoulder. Designs should be kept a safe distance from seams. The tolerance for a multi-color design registration should be plus or minus 1/32" on small containers and 1/16" on gallon size bottles. Reverse copy in heavy ink areas should be large enough to allow for a slight ink spread. Very small copy is a problem unless the ink is slightly modified. Some bottle manufacturers make the bottle with wedge slots at the bottom for better register control. Artwork and mechanicals must be sharp and clean for photographic reproduction. Mechanicals may be slightly larger to allow for increased sharpness in the reduction, to make the film negative and positive. Mechanicals should be reduced to scale.

FLAME TREATING

We wish to state that the duPont Company has a method patented in flame treating and anyone attempting to flame treat should contact the duPont Company. They will be happy to supply additional information regarding flame treating.

We mentioned that many items produced from polyethylene are decorated or printed and much of it is silk screen printed. Polyethylene, with its untreated surface, is almost completely inert chemically (a desirable characteristic), but this produces poor printing result. Flame treating makes the polyethylene receptive to inks by oxidizing the surface. Flame treating is a very critical step in the production of printed polyethylene items. To assure proper and complete surface oxidation an air/gas mixture rich in air, is therefore necessary. Ideal fuel ratios are ten parts air to one part natural gas or twenty-five parts air to one part propane gas. Where flow meters are not available, ink adhesion tests should be run at various full mixtures or valve settings. The proper air/gas ratio blend will result in a purplish-blue flame, hardly discernable in a lighted area, but easily seen in darkened areas. The surface should pass 1/8" to 1/4" away from the distinct, cone shaped, bright blue flames. Dwell time through the flame varies. Gravity drops do not allow sufficient time for proper oxidation in most cases. Chutes and flat conveyor belt arrangements have proven very successful. There must be a complete absence of yellow in the flame as this indicates too rich a mixture. The test procedure for proper flaming is to immerse the bottle into cool water and withdraw it slowly. If a water film remains, the bottle is flamed. Too long a flame treatment will melt the surface resulting in a non-receptive surface. A properly flamed surface may stay as long as six months, depending on many variables. The theory is that the polyethylene molecules migrate out through the flamed surface and the item must be flamed again. Both jarring of items in transit and skin oils make for non-receptive ink areas. In some cases, mold release agents have prevented proper and adequate flame treating.

SILK SCREEN PRINTING PLATES

The silk screen plate carries the desired stencil image on a mesh material, silk or wire, stretched drum tight on to a wood or metal frame. Apertures in the mesh are blacked out to allow ink to pass through, resulting in the desired image. The blackout procedures for silk screen decorating of polyethylene blown ware includes the hand-cut stencil, the pre-sensitized emulsion on a temporary support and the pre-sensitized emulsion coated to the mesh.

A. The hand-cut stencil which consists of a lacquer film attached to a temporary support, such as vinyl acetate or mylar. The stencil cutter cuts only the lacquer film and does not score the backing support. The cut stencil is then affixed to the mesh by placing the screen on top of the stencil and mesh is swabbed with a lacquer solvent which

softens the lacquer and imbeds it into the mesh. After all the solvent is evaporated, the temporary support is removed and the open mesh areas close to the frame are blocked out.

B. The pre-sensitized emulsion on a temporary support is exposed to the carbon arc with the positive or negative on top of the emulsion which is then applied to the silk wet, after washing out the unexposed emulsion with water. This is left to dry and the backing sheet is removed with the same procedure for blockout as the hand-cut stencil.

C. The third method is used by most of the polyethylene bottle decorators where the pre-sensitized emulsion is applied to the mesh and after drying for twenty to thirty minutes, the entire screen is exposed to a black light fluorescent lamp. The exposed areas are washed out with water and, after drying, are ready for screening.

SILK SCREEN PRINTING EQUIPMENT

Silk screen decorator presses are either hand fed or completely automated. Hand operated cylindrical jigs are available for printing rigid walled polyethylene items or bottles. Automatic printing presses are designed with air-inflating devices to make the bottles rigid enough for silk screen printing at high speeds. Check for consistent wall thickness throughout the container, since variations in the wall thickness lead to non-printing areas. After the silk screen plates are secured to the press carriage, they are moved left-to-right with air or gear-driven devices. Warehouses are usually gear-driven and synchronized with the lateral movement of the screen plate.

Cylindrical silk screen decorator presses come equipped with stationary vertical squeegees (rubber or plastics bladed ink distributors). The rubber blades are V-shaped and down pressure is adjustable. Blades are sometimes shaped to a bottle contour to aid in sharper printing. With the introduction of plastics blades, prints of up to 1/2 million have been made without blade sharpening or blade fatigue.

SILK SCREEN PRINTING INKS

Proper adhesion of the ink is of prime importance. We stated the necessity of proper and adequate flame treating. It is also important to have controlled compounding for best ink adhesion. Improper compounding is the result of the addition of too much mold release agent to the polyethylene.

The inks most widely used are synthetic alkyd in nature. They call for prolonged curing cycles. Though the inks are dry enough for random oven end belt collecting, thorough curing takes three to seven days. This means that the ultimate in adhesion and product resistance will not be attained until the end of this period. Air-dry overnight or twelve to fifteen minutes at 185°F. Thorough curing is accomplished in forty-eight to sixty hours for product resistance. The pot life of this system is six hours after the catalyst has been added.

All the mentioned ink systems have modifying additives, solvents and body compounds to aid in a specific decorating situation.

STATIC AND DUST

During the silk screen processing and decorating of polyethylene blown ware, static and dust sometimes present problems. The dust on the item transfers to the underside of the silk screen plate and builds up, leading to filled-in open mesh areas. Bottle brush and static bar assemblies have proven very helpful in eliminating dust and static. With the elimination of dust and static, the silk screen plates print continuously, making fewer stoppages and washups.

About the Author........

Gene Krupinski started working for Poster Products of Chicago in August of 1934. In 1941 he was placed in charge of Poster Products Silk Screen Printing Department.

In 1950 he joined Sinclair & Valentine in Chicago. Recognizing the future for plastics, Gene left Sinclair & Valentine in 1955 and took a position as Production Supervisor with Kalmus and Associates, who were large in the use of plastics. He rejoined Sinclair & Valentine, Chicago, in 1958, and in July 1961 was appointed National Sales Manager of the Silk Screen Division with headquarters in Kansas City.

DECORATING THE PLASTICS BOTTLE

L. E. Ritter

Field Service Engineer

Bee Chemical Company

Lansing, Illinois

The blown polyethylene container brought about a marketing revolution in the distribution of many products. You walk down the aisles of any supermarket and this fact is very obvious. As you see row on row of these another fact also becomes obvious. Manufacturers have realized that if they did not give their own bottle a distinctive appearance then their brand would be lost in the forest of white bottles.

Some of these manufacturers have attempted to overcome this through the shape of the bottle. The pinched waist, the handle and the various fluted shapes are all intended to give the manufacturer a stand-out package. The label has provided another means of brand identification which simultaneously solves the problem of listing the contents and instructions for use of the product.

But the manufacturer, his designer and sales manager have found added sales appeal in another area -- color. The consumer reacts to color and, all other factors being equal, the decorated package is the one that sells. For example, for many years there were over a dozen liquid and powder bath products for children on the market but most of them just sat on the store shelf and only a couple were even mildly successful. Some made a limited appeal to the youngsters by featuring cartoons on the cartons. The market was there but no one fully realized its potential until Colgate's Mickey Mouse and Donald Duck packages made the market really come to life with the introduction of a liquid bath soap called Soaky. Other figures followed and this product literally quadrupled the market. The kids grabbed them and their mothers did not object because it turned what is usually a painful process - getting Junion into the tub - a time of fun.

Uncolored bottles might have sold the product to some extent, but I think it is obvious that color is what put the product on top. The polyethylene bottles are blow-molded in various base colors. The additional colors for each figure's dress and face detail are spray-painted. The paint was especially developed for this application by our company. Ordinary plastics paints will not adhere to polyethylene or polypropylene. Normally, in painting plastics you get adhesion by one of two methods or a combination of both.

Intermolecular attraction, signified by the magnet, depends on the polarity of the plastics. The molecules of polyethylene and polypropylene have inert, non-polar hydrocarbon structures so attraction is not possible. These plastics have a low solvent sensitivity so etching or attacking of the surface to provide "hooks" for the paint is also not possible. These plastics therefore must be treated prior to decorating, either through flame-treating, chemical treating or electro-

treating. A paint was developed that would adhere to these plastics following treatment. In the case of the Soaky figures, flame-treating was used prior to decorating. The coating was developed to meet other requirements. The paint had to be non-toxic and pass three tests specified by Colgate for adhesion to the plastics, a water-immersion test and an elevated temperature test. The coating passed with flying colors and other manufacturers got on the band-wagon. In addition to these tests these coatings have to provide a fast touch-dry because of the demands of volume production and immediate packaging. They have to be sprayable by hand-spraying or automatic methods. The painting of these bottles has reached a mass-production level that brings it closer into line with other methods of decorating these bottles such as the application of a label. Decorated Products, Inc., who was the finisher for many of the Soaky bottles, reported quantities of 70,000 units per day on a 3-shift operation, close to 3,000 bottles an hour.

Screening is another method of achieving color on blow-molded bottles. Here production speeds vary anywhere from 200 to 1200 bottles per hour depending on the shape of the bottle. The amount of decoration detail and number of colors. But a good reported average for a 2-color decorated bottle is 1,000 per hour on automated equipment. Here again a coating that is compatible with the plastics must be used. Requirements for a screening coating also include good handling in the screen and good gloss, rapid-drying and resistance to the product that is to be packaged, whether this be a detergent, floor wax or glue. The design of the bottles must take into consideration the method of decoration to be used - whether painting or screening. The more irregular the shape the harder it will be to flame-treat the surface. For that reason, you may have noticed the Soaky figures were painted on one side only. The shape will also naturally affect the cost of decorating and the masks to be used.

The designer has found a truly versatile medium in the painting or screening of these bottles. The imaginative use of color sells products. The properly decorated bottle stands out among the others -- looks the consumer right in the eye and says "Buy me!"

About the Author........

L. E. Ritter was born in the greater St. Louis area. He attended Shurtliffe College and Washington University, St. Louis.

Mr. Ritter first started working for a major oil company in their laboratory. He later transferred to their Industrial Sales Division. After leaving the oil company, Mr. Ritter became district manager for F. J. Stokes in Philadelphia. He joined his present employer, Bee Chemical Co., in 1960 as a Field Service Engineer.

THE RECIPROCATING SCREW BLOW MOLDER

Herman R. Hutchinson

Product Specialist

F. J. Stokes Corporation

Philadelphia, Pennsylvania

I think it can safely be said that development of the reciprocating screw or accumulator type of extruder for blow molding was a natural refinement of the art looking toward both better quality and lower cost. Both of these methods of extrusion had as their basic purpose, a desire on the part of machine builders to eliminate poor quality of finished molded parts resulting from neck-down of the parison, as well as an equally compelling need to lower cost by eliminating a substantial part of the molding cycle.

Let us take a quick look at the savings in cycle time first. Many of our customers have to stop and think a bit before they realize that there is a substantial increase in output from reciprocating screw or accumulator type machines as compared to straight extruders operating with dual moving molds or dual press sections. The difference comes, of course, from the fact that the straight extruder must be operated at a speed that will deliver a parison in a period of time equal to the cooling time for the particular part being made. The extruder must extrude continuously. Therefore, parison delivery to one mold must equal the time the other mold is closed for cooling, plus perhaps another two seconds to allow the opposite mold to open and have the finished part removed. For instance, if twelve seconds is required for cooling and two seconds for opening and part removal, another fourteen seconds is required for parison delivery and the total cycle is twenty-eight seconds. With the receiprocating screw or accumulator, provision is made for delivering a parison on an interrrupted basis with a much faster rate of delivery. Two seconds would be considered an average parison delivery period for many jobs so that the total cycle in the example above, could easily be twelve seconds cooling, two seconds mold opening and part removal and two seconds for parison delivery for a total of sixteen seconds.

This is a seventy-three percent increase in production rate, a figure not often equalled in improving production machinery. The confusion among customers mentioned earlier results from the fact that they realize there are still two molds to cool so they jump to the conclusion that the overall cycle must still be twenty-eight seconds, with the extruder sitting idle for the time saved. The fallacy in their thinking can be disclosed by tracing the sequence of operations in the dual press section type of operation.

Assume we are starting up a reciprocating screw blow molder. First, a parison is delivered to one mold in two seconds. This mold is then closed on the parison, and blow and cooling start in this mold. Simultaneously a three-way valve in the manifold between the extruder and parison die moves so as to block the extruder nozzle and the extruder starts to plasticize the next shot. Eight seconds after starting delivery of the first parison the three-way valve shifts, connecting the

extruder to the opposite parison die and in two seconds another parison is formed. The extruder must therefore have plasticized this next shot in less than eight seconds. At the end of twelve seconds of cooling the first mold opens, two seconds more are allowed for mold opening and part removal after which the next parison is delivered to the first mold. Total elapsed time is sixteen seconds.

Perhaps this would be a good point to inquire as to the minimum cycle obtainable with this type of equipment. This is determined largely by the part and by mold design, but with ideal conditions some molders are now working in the area of twelve to fourteen seconds. Multiple heads can be used so that a machine with dual heads and dual press section is capable of producing up to twelve-hundred pieces per hour. Multiple cavity molds or larger machines with quadruple heads increase this yield proportionately. A real advantage of this type of machinery thus becomes apparent, and I refer, of course, to its flexibility. A molder can get production efficiency that makes him competitive in the container field at very modest mold cost and he can still handle the broad gamut of industrial, toy and housewear items that are now providing much of the potential for this industry.

The other big advantage of the reciprocating screw or accumulator type of extruder is the rapid parison delivery and resulting minimizing of neck-down. Variation in parison wall thickness, type of material being used and length of parison all help to determine the amount of neck-down so that statistics must be quoted with reference to these factors. We recently had a good example of this phenomena in our Plastics Laboratory. We were using a parison die with 3-1/4" diameter and an annular opening of .060" and forming a 12" long parison. Our normal operation gave us an average difference in wall thickness from top to bottom of the finished piece of .003" or about 8%, in this particular case. We purposely cut our injection pressures to simulate straight extruder output and got .007" or about 19% variation in thickness in the vertical direction.

One objection that you may have raised a few moments before could have been about the amount of time in the cycle that the extruder is not plasticizing. It is perfectly true that as much as 40% of the time in the overall cycle can be spent injecting and shifting the rotary valve, but we have more than compensated for this by putting plenty of power in our equipment. Our 3-1/2" extruder, for instance, has a 75 horsepower motor and is capable of a net output of over 300 pounds per hour. The additional investment is small as compared to the tremendous increase in productive capacity.

Another advantage of the reciprocating screw or accumulator type of operation is the control of part weight obtainable by changing the injection pressure. It is well known that higher pressures produce thicker parisons and therefore, heavier parts. It is not so widely known that part weight can also be changed by operating in different zones of the available stroke of the screw, and we assume the same would also be true of the accumulator system. As an example, our 3-1/2" machine has a shot capacity of four pounds all of which is rarely used. If we are making a one pound shot we will use only one-quarter of the available stroke, and we have the option, therefore, of working in the forward, middle or rear zones of the full stroke. Table I shows the variation in part weight obtainable with changes in injection pressure and in the working zone.

Another feature of these systems is the variable pressure on the plastics available during the plasticizing part of the cycle. We provide for a range of between 200 and 500 pounds on the hydraulic injection cylinder during this part of the cycle so that optimum melt and color mixing conditions can be obtained for various materials and molding situations.

Thus far I have been discussing the common advantages of the reciprocating screw and the accumulator for blow molding applications. There are additional points which we feel indicate that the reciprocating screw is the better of these two systems.

The differences are the kind that lend themselves to basic principles of design rather than to statistical comparison. First, and most important, is the straight through flow of material in the reciprocating screw as compared to the inevitable dead spots in flow pattern when material is alternately forced into an auxiliary chamber from one port and then out another. This leads to possible degradation of material caught in these slow moving areas and it also makes color changing a very costly job.

We also like the full hydraulic system which eliminates the thrust bearing. The screw is driven by an hydraulic motor and is normally stopped by a limit switch. The position of this switch is adjustable for operation in different zones of the full stroke as mentioned above. In addition to this switch we have a duplicate one at the full limit of travel to the rear, this one acting as a safety switch in case the first one fails. If both of these fail or if the valve they operate fails we still have the safety relief valve in the system which would open as soon as the screw "hit bottom". The screw is therefore operated between two fluid systems at all times with consequent cushioning of shock loads.

The accumulator systems in use today have one common problem caused by the fact that the screws are not generally hydraulically driven. During the injection part of the cycle high pressures are usually developed on the melt and a check valve is commonly provided at the outlet of the extruder to prevent this pressure from damaging the extruder thrust bearing. When this valve closes the extruder must stop or its output must be bypassed. This complicates the design and even exposes the thrust bearing to danger if the check valve does not seat properly. It is, of course, possible to use a big enough thrust bearing to withstand the injection pressure, but this usually results in limiting this pressure to levels that materially lengthen parison delivery time.

In short, we feel that the reciprocating screw has all of the advantages and none of the disadvantages of the accumulator.

About the Author........

Herman R. Hutchinson graduated from Lehigh University in 1937 with a B.S. in Industrial Engineering. From 1937 to 1955 (with the exception of four war years when he was in the Navy, 1941-45) he was with C. F. Rump & Sons of Philadelphia, manufacturers of leather goods, where he eventually became Vice President in charge of Production and Product Design.

From 1955 to 1963, he was Vice President of Plastimatic Corp., Malvern, Pa., in charge of Sales and Production. His work here was concerned with the production of containers for food packaging and he developed several types of sealed plastics containers as well as machinery for sealing them.

In July, 1963 Mr. Hutchinson moved to F. J. Stokes Company in Philadelphia.

EUROPEAN BLOW MOLDING TECHNOLOGY AS EMPHASIZED AT THE DUSSELDORF KUNSTSTOFFE, OCTOBER, 1963

Allan L. Griff

Plastics Consultant

Edison Technical Services

Metuchen, New Jersey

The report will include an illustrated description of blow molding machinery and techniques, as used in the European blow molding industry. It will include the very latest developments, as seen at the Dusseldorf Plastics Exhibition in October, 1963, and will cover such items as methods to control parison wall thickness, multi-colored products, rotary (multiple-mold) machinery and blow molding of rigid PVC and other less common materials. Photographs and/or samples of interesting objects blow molded in Europe will also be shown.

Because of the timeliness of this subject, it is impossible to include this report in the preprint. It is hoped, however, that Mr. Griff will have had time to prepare a supplement which can be distributed at the RETEC.

About the Author........

Allan L. Griff hails from New York. He graduated from Cornell University in 1954 with a B.S. in Chemical Engineering.

He worked briefly for both Gulf Oil Company and Cornell Chemistry Department. He was next employed in Technical Service and Development Departments of Union Carbide for over six years, specializing in extrusion and other thermoplastics processes.

Since 1961, Mr. Griff has been Director of Edison Technical Services, Inc., doing consulting and reporting in the areas of thermoplastics processing and specializing in international communication of technical information. Major projects include managing a stand at Europlastique (French International Exhibition, 1962) for five American clients and issue of semi-annual patent analyses on worldwide developments in extrusion and other processes.

Writings: Author of book, PLASTICS EXTRUSION TECHNOLOGY, published by Rheinhold in 1962. Feature reports on European Plastics Industry and World Plastics Industry, in Chemical Week (5/12/62), Plastics Technology

About the Author (Cont'd.)........

(Sept. 1962), and Modern Plastics (August 1963). Many other technical articles in American, British and German journals. Book reviews in SPE Journal, Chemical Engineering Magazines. He has delivered papers at SPE ANTECS 1958 and 1959, and was guest speaker at National PAG Meeting for Forming, ANTEC 1962.

Al Griff is a member of SPE (Newark Section); Forming PAG; SPI (Professional Member); Chemists' Club; Cornell Society of Engineers; Plastics Institute (Great Britain).

SOCIETY OF PLASTICS ENGINEERS, INC.

National Executive and Business Offices
65 Prospect Street
Stamford, Connecticut

APPLICATION FOR MEMBERSHIP

Gentlemen:

I hereby make application for membership in the Society of Plastics Engineers, Inc. on the basis of my training and experience given herewith. I wish to affiliate with the ____________________ Section. (Geographical Location)

I certify that the statements made in the record of my training and experience are correct. I agree, if elected, to be governed by the Constitution, By-Laws and Rules as long as my connection with the Society shall continue. I agree to promote the object of the Society as far as shall be within my power.

____________________ Date of application.

____________________ Signature in ink.

REFERENCES

The By-Laws require the names of three men who are familiar with your work. One of them should be a member of the Society. Assistance in providing member-references when needed will be provided on request to National Office or Section.

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3. ____________________ Address ____________________

ADDRESSES—Please print or type

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Please fill in both addresses and check one to which mail should be sent. (Advise immediately of any change)

☐ Business: Company Name: ____________________

Street No.: ______ Street: ____________ City: ____________ Zone No. ____ State: ______

☐ Home. Street No.: ______ Street: ____________ City: ____________ Zone No. ____ State: ______

APPLICANTS: Do not write below this line on this side.

COMPLETE BOTH SIDES OF THIS APPLICATION

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(This Record must be completed by the local section)

Report of Application to Nat'l. Office (Blue Copy) Date ____________

Submitted to Section Credentials Committee Date ____________

Years of credit given for:
Education ____________
Experience ____________
Total ____________

This man is classed as a:
____Senior Member
____Associate Member
____Junior Member
____Student Member

____________________ Date ____________
Signature of Chairman Section Credentials Committee

Approved by Section Board of Directors, Date ____________

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Signature of Section Secretary

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Signatures of National Credentials Committee

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RECORD OF EDUCATION

Technical education and the holding of a degree are NOT necessary to qualify for membership, however credit will be given on the following basis in lieu of, and in addition to qualifying experience: Doctorate in technical subject - 5 years; Masters in technical subject - 4 years; Other in technical subject - 3 years; Other in non-technical subject - 2 years.

SCHOOL	PLACE	ATTENDANCE		MAJOR SUBJECTS
		FROM	TO	

Degree of ______________________ from ______________________ date ______________

PRESENT OCCUPATION

Title or Position ______________________ Name of Company ______________________

Company address ______________________

Nature of work done by company ______________________

Explain in detail, the nature of your work and responsibilities ______________________

RECORD OF QUALIFYING EXPERIENCE

In the space below, supply complete record of past connections in detail. Describe duties fully and state briefly any important engineering work you have done. If space is not sufficient continue record on separate sheet of same size. **Your proper classification depends greatly upon the clarity of your record of experience and the degree of technical knowledge or skill required.**

DATES	NAME AND ADDRESS OF COMPANY	TITLE or POSITION	*RESPONSIBILITIES

PROFESSIONAL ACTIVITY GROUPS — CHECK ONE OR MORE OF PRIMARY INTEREST

- ☐ Casting and Plastic Tooling
- ☐ Finishing
- ☐ Metals for Plastic Molds
- ☐ Plastics In Electrical Insulation
- ☐ Standards for Reporting Properties
- ☐ Extrusion
- ☐ Forming
- ☐ Plastics in Buildings
- ☐ Polymer Structure and Properties
- ☐ Thermosetting Molding
- ☐ Fabricating
- ☐ Injection Molding
- ☐ Plastics in the Automotive Industry
- ☐ Reinforced Plastics
- ☐ Vinyl Plastics

COMPLETE BOTH SIDES OF THIS APPLICATION AND MAIL WITH INITIATION FEE TO S.P.E. OFFICE